The regional impact of technological change in 2020

Framework Service Contract
150083-2005-02-BE
(Ref SC36 Regional Impact)

Synthesis report

Final version

René Wintjes and Hugo Hollanders (UNU-MERIT)

with input from the ETEPS project partners:
Austrian Institute of Technology (AIT)
Centre for Decision Sciences and Forecasting, Progress & Business Foundation
Fraunhofer ISI
Fondazione Rosselli
OPTI Foundation
Technology Centre of the Academy of Sciences CR

For Directorate-General Regional Policy

On behalf of:
The network for European Techno-Economic Policy Support
ETEPS AISBL

TABLE OF CONTENTS

Executive Summary

Regional diversity in models of innovation in Europe

This study highlights the great diversity in development pathways and trajectories of innovation across European regions. A regional knowledge-based economy has multidimensional 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.

Today's innovation landscape shows an increasing shift from technology-push policies towards demand-pull policies. Promoting applications, user-driven innovation, innovation in services and in the public sector and addressing societal challenges have increasingly shaped the innovation policy agenda. The study moves beyond a linear research-based approach to innovation and encompasses a broad set of social, economic and institutional framework conditions. Besides R&D indicators for access to knowledge and technology, indicators for absorption and diffusion are also included.

Key determinants: Accessibility, absorption and diffusion capabilities

A region's position towards knowledge and technology is determined by three features:

1. the accessibility to knowledge;
2. the capacity to absorb knowledge and;
3. the capability to diffuse knowledge and technology.

Accessibility to knowledge is dependent on local infrastructure, connectivity, proximity to markets, incidence of knowledge institutes, R&D and innovation activities and networks. Absorption capacity depends on the level of skills, education, equipment and professional networks, and on the availability of knowledge intensive services. Diffusion capability is determined by factor mobility, density, high-tech manufacturing, international trade and foreign investments.

Conclusions at regional level

- Regional innovation is relevant for all regions in Europe: in technologically leading regions to remain ahead, in peripheral regions to catch up, but innovation strategies should differ.
- The impact of knowledge and technology factors on GDP per capita varies significantly across different types of regions. For lagging types of regions (Traditional Southern, Skilled industrial Eastern European, and Public Knowledge centres) Business R&D has a positive impact on GDP per capita while for other, wealthier EU regions, education and training have a positive impact on GDP per capita.
- Absorption capacity has become a very important dimension of regional knowledge economies in Europe and education and training is the most important challenge for future regional development.

- Specialisation in either 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.

- In all types of regions cross-sector linkages are important drivers of innovation.

- At regional level, application of technology is more important for future innovation then hosting basic research.

- Many of the sectors considered promising for the future are quite traditional, e.g. transport and agriculture. Cross-sector fields of specialisation, application of new General Purpose Technologies in existing sectors, and specialising in specific niches in the innovation landscape (smart specialisation) are considered to be most promising for the future.

- Lack of risk capital is a major barrier to regional innovation. Other barriers include limited production, transfer and use of knowledge, limited cross-sectoral collaboration, lack of entrepreneurship, and the long-term negative effects of the financial crisis on R&D funding.

Conclusions for EU policy

- Further integration of the European knowledge economy increases the importance of regional specialisation.

- Excellence-based and place-based innovation policies can be mutually compatible. While scientific excellence (-based policy) may not be very important for every region, place-based specialisation and innovation policy is. Excellence-based competition can be helpful in discovering areas of smart specialisation as it forces in their competition with other regions to search for a niche.

- Place-based innovation policy is essential to enhance knowledge absorption and diffusion capacities and encourage smart specialisation. Smart specialisation is a promising way for each region to maximize the benefits of technological change and regional innovation potential.

- Excellence in technology generation does not necessary lead to regional economic benefits. Even those regions which would benefit most from excellence-based research policy might need place-based innovation policy to enhance knowledge absorption and diffusion capacity in order to maximize regional impact.

- Public policy at the EU level has an important role to play in fostering place-based, smart specialisation policies.

- Adequate capacity for innovation-oriented policy formulation and implementation at regional level is essential.

- Especially in the lagging regions it is important to improve basic framework conditions, including the quality of government in general and the governance of innovation policy in particular.

1. Introduction

The main purpose of this study "The regional impact of technological change in 2020" 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 study's main research questions are:

1. 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.

2. 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 study 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.

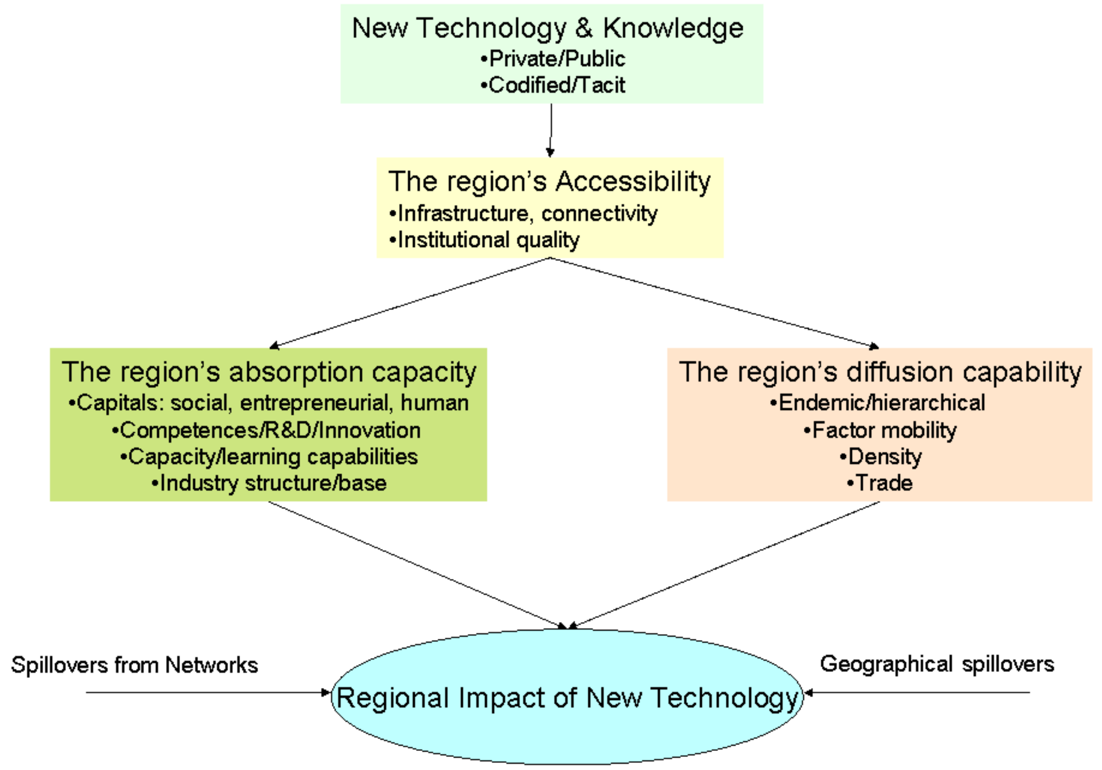
Chapter 2 will discuss the framework conditions for the regional impact of technological change by focusing on the relevance of three different concepts: the accessibility to knowledge, the capacity to absorb knowledge and the capability to diffuse knowledge. In Chapter 3 provides a new regional typology of 7 different types of regions by implementing the framework developed in Chapter 2 using a wide range of statistical data and discusses the policy relevance of this typology. Chapter 4 discusses different pathways of innovation. Chapter 5 summarizes the results of the foresight study at the EU level and discusses EU level policy conclusions. Chapter 6 provides a more detailed discussion of the foresight results for the 7 different types of regions including a SWOT analysis. Chapter 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 the literature report of this study). Figure 2.1 shows the graphical visualisation of how new technology has an impact on regions.

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 2.1 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"[1] 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.

---

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

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".

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[2] 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.

[2] 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

By 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

The above factors have then been used to identify seven different types of regions using hierarchical clustering analysis (figure 3.1 and 3.2):

- 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 3.1 shows the average factor performance for the different types of regions and Figure 3.2 shows the geographical illustration of the regional typology.

Figure 3.1 Average factor scores per type of region

Note: 0 is the average of all European regions.

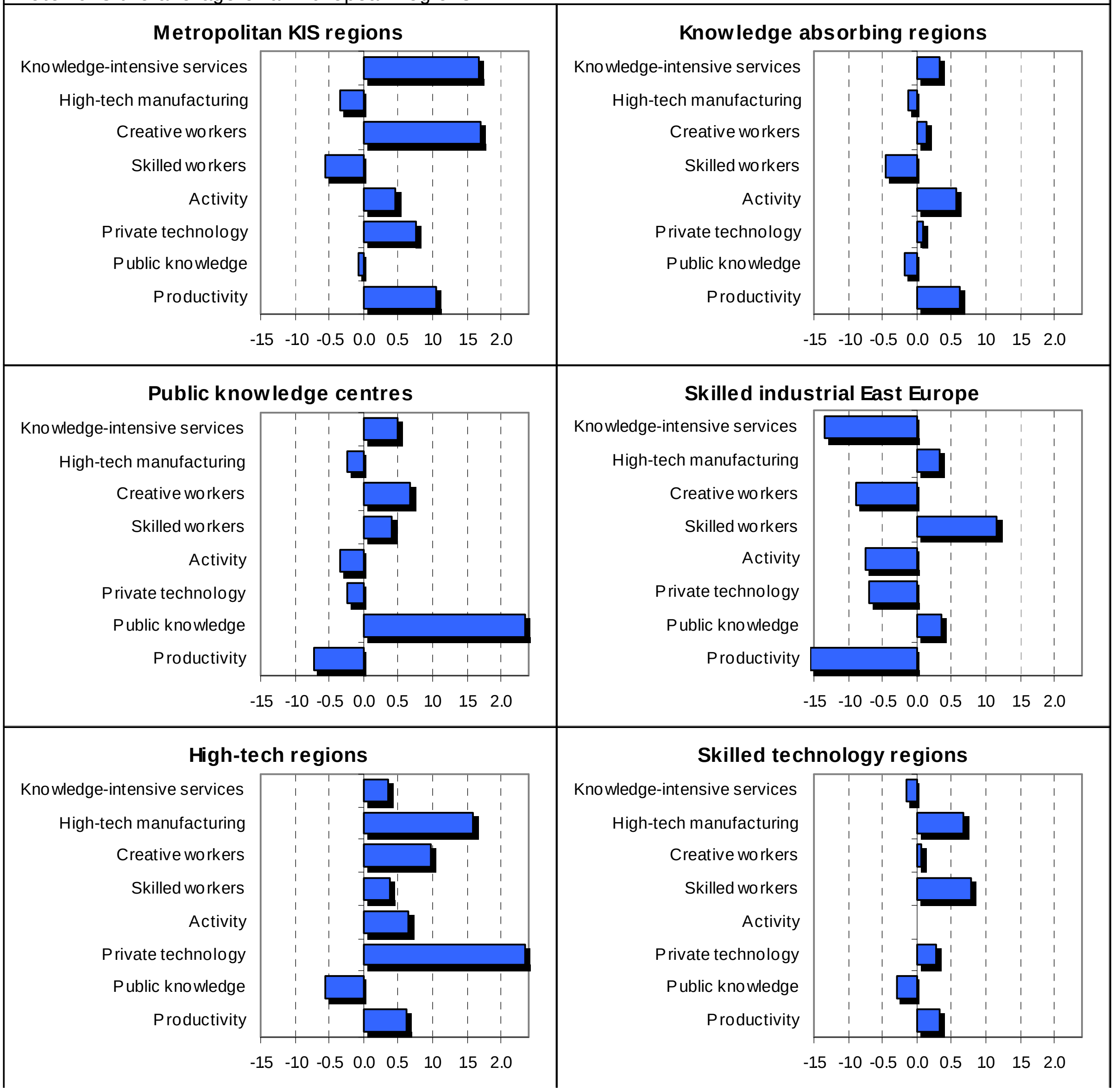
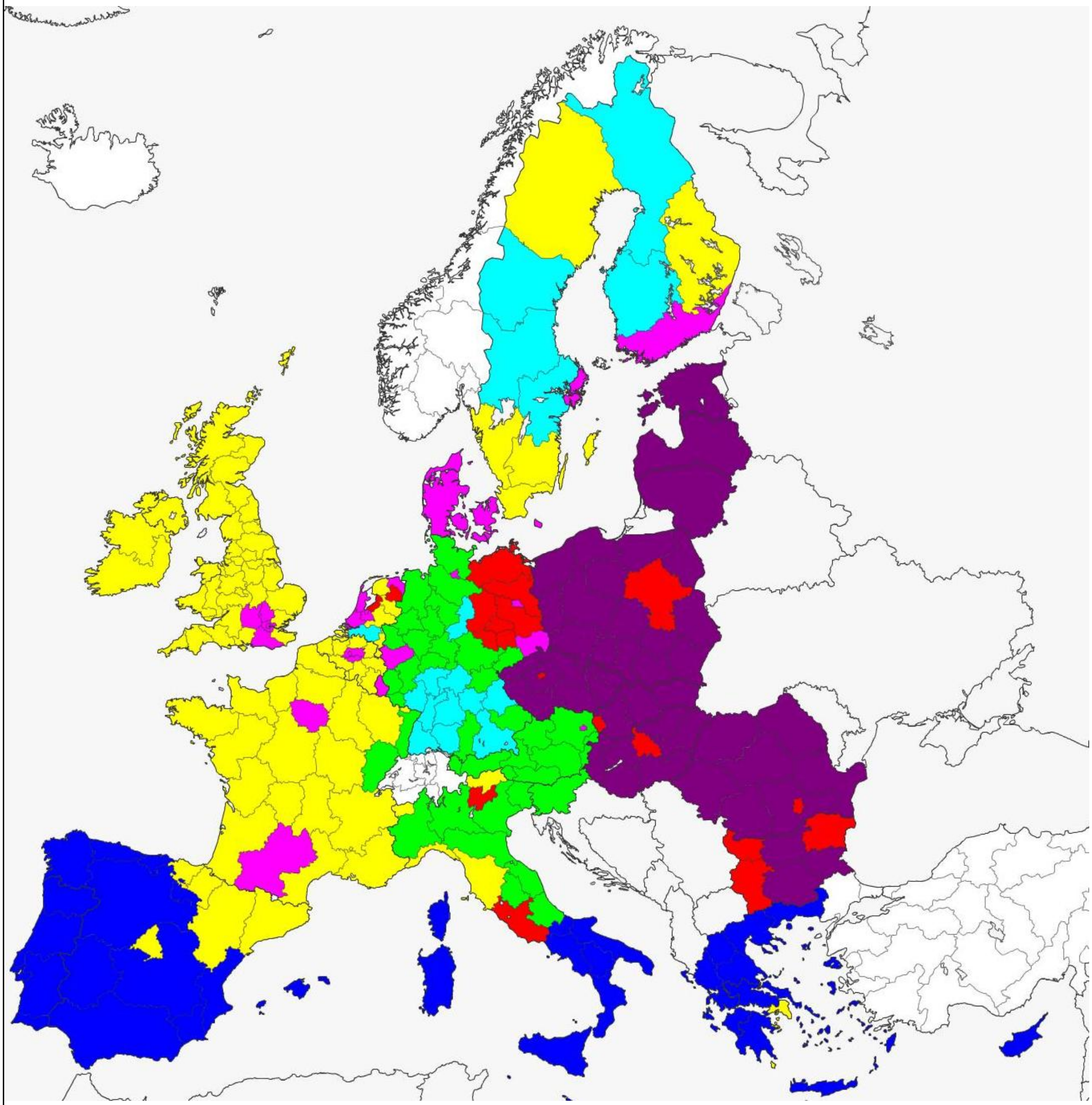


Figure 3.2 Regional typology



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 3.1).

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 3.1 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. Chapter 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 chapter 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.

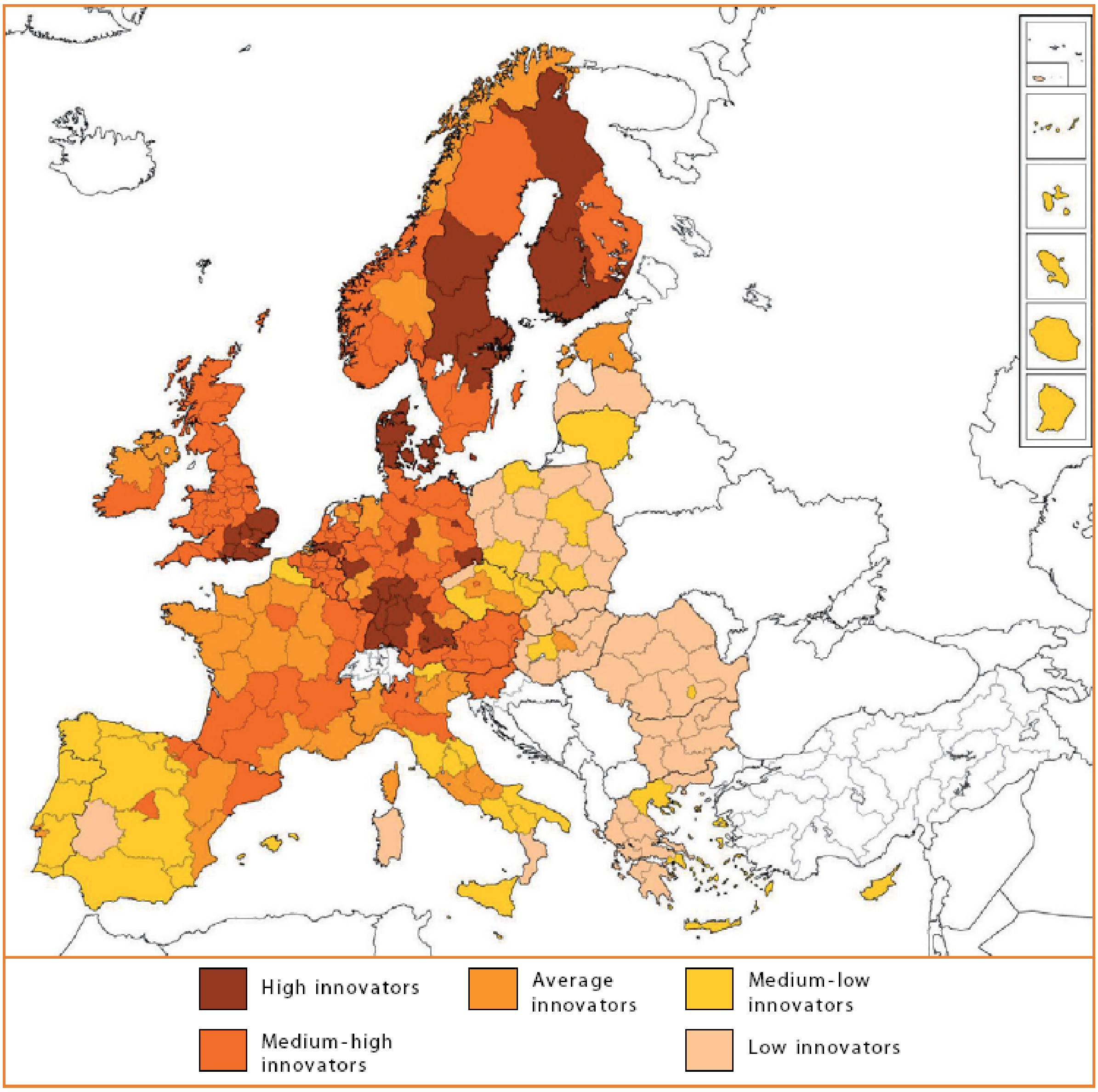
Differences in regional innovation performance

The 2009 Regional Innovation Scoreboard (Hollanders et al., 2009) shows a considerable diversity in regional innovation performance across Europe (cf. Figure 3.3) 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.

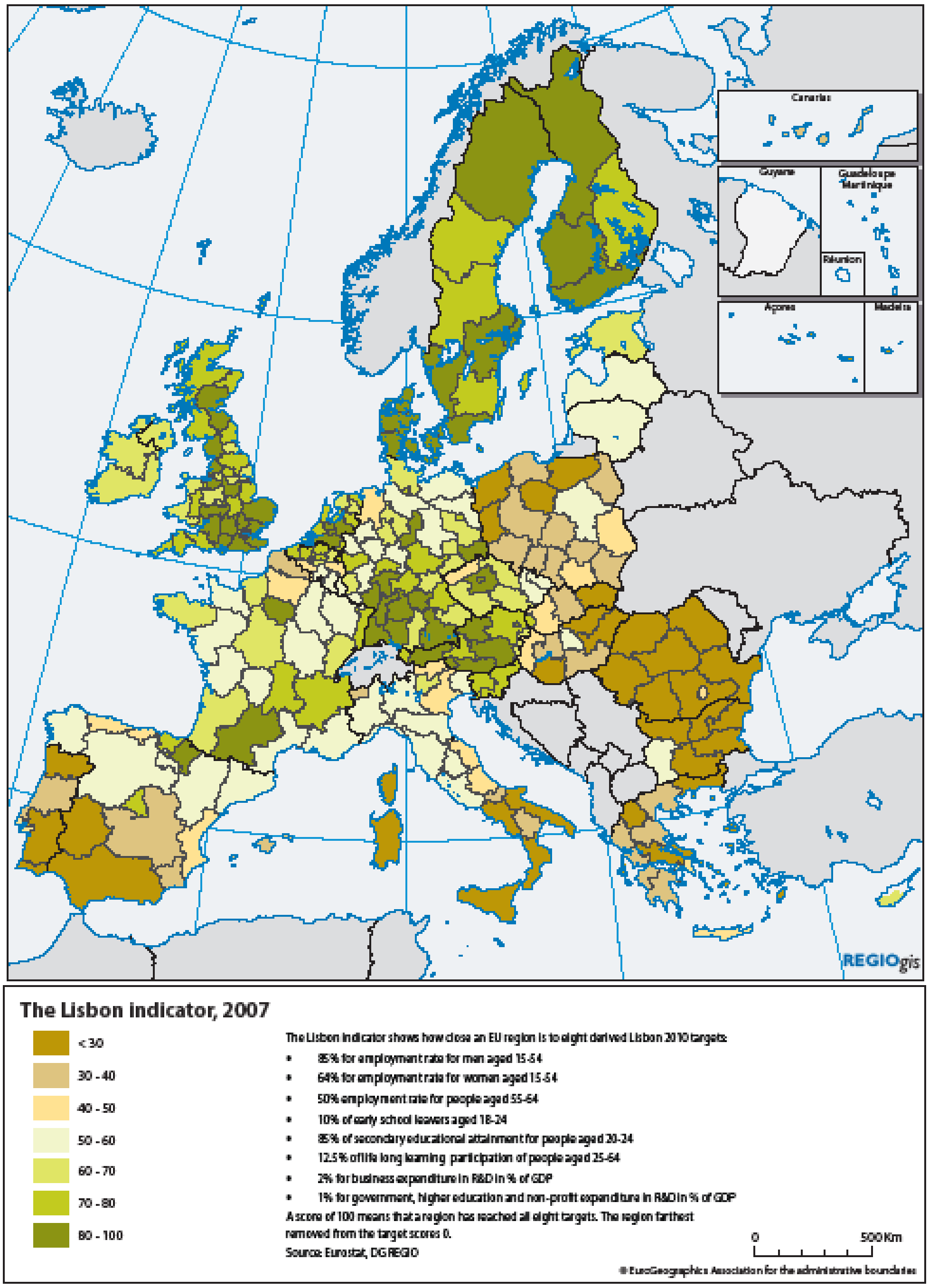
Among the high innovating regions we only find High-tech and Metropolitan KIS regions. Except for one region being a medium-high innovator all High-tech regions are high innovating regions and all Metropolitan KIS regions are either a medium-high or high innovator. Similarly, most Traditional Southern European and Skilled Eastern European regions are either a medium-low or low innovating region.

Figure 3.3 Regional innovation performance



Source: 2009 Regional Innovation Scoreboard (Hollanders et al., 2009).

Figure 3.4 Map showing performance on Lisbon indicators



Diversity among leading regions as well as among lagging regions

Comparing the regional typology with the map showing regional performance on Lisbon indicators (Figure 3.4 Lisbon 'distance' map) suggests the following differences:

Firstly, the two least performing types of regions (Skilled Eastern EU and Traditional Southern EU regions) in the regional typology are taken together in the least performing category of the Lisbon distance map, which however hides the difference between the two types of regions.

Secondly, in the Lisbon indicator map the best performing category of regions consist of both Metropolitan KIS and High-tech regions, while in terms of knowledge, research, technology and innovation these two types of well performing regions differ considerably.

Thirdly, the largest, middle groups of regions remain diffuse in the Lisbon map, while the regional typology shows significant variations between them.

The above distinctions in the regional typology are partly based on sector difference. Skilled industrial Eastern EU, High-tech and Skilled technology regions are more oriented towards manufacturing industries compared to Traditional Southern, Metropolitan KIS and Knowledge absorbing regions respectively.

Similar observations emerge from comparing the regional typology with a map showing GDP per capita at regional level (Figure 3.4). 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, spill-overs 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:

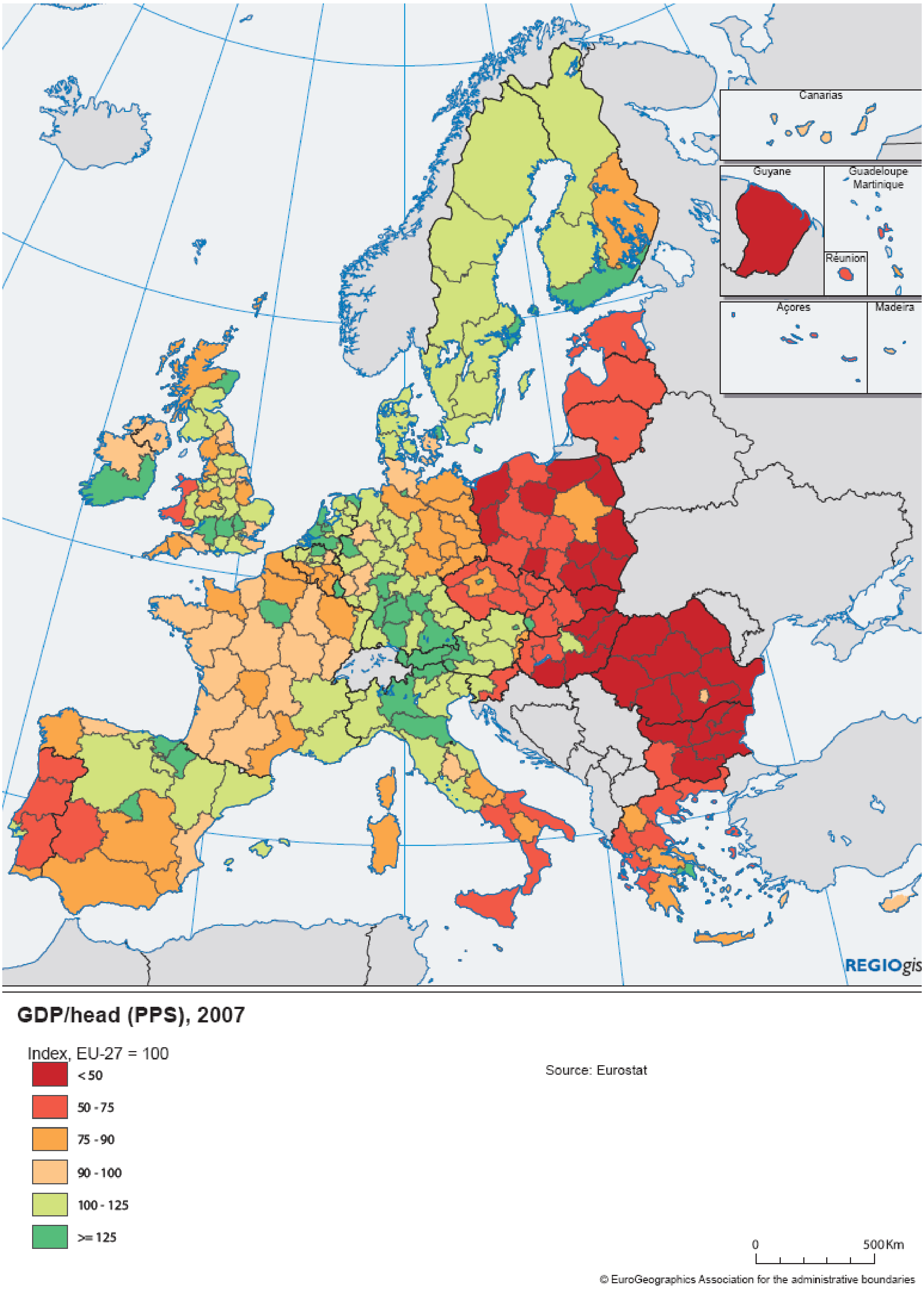
- Metropolitan Knowledge Intensive Services regions are often surrounded by Knowledge absorbing regions.
- Many High-tech regions serve as (technological) core to surrounding Skilled technology regions.
- Two capitals in the South (Knowledge absorbing regions) are surrounded by Traditional Southern regions.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

Figure 3.5 GDP per capita at regional level in Europe, 2007



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 4.1 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)	

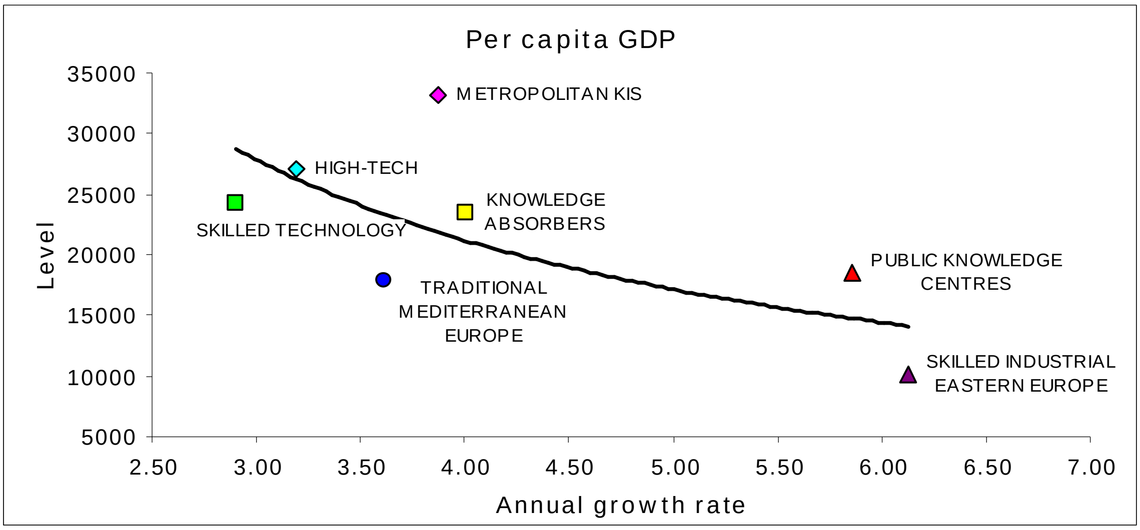
Note: Indicators which show (significant) divergence are in bold

Convergence occurs for most indicators (table 4.1)[3], 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 4.1. 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.

[3] 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 4.1 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

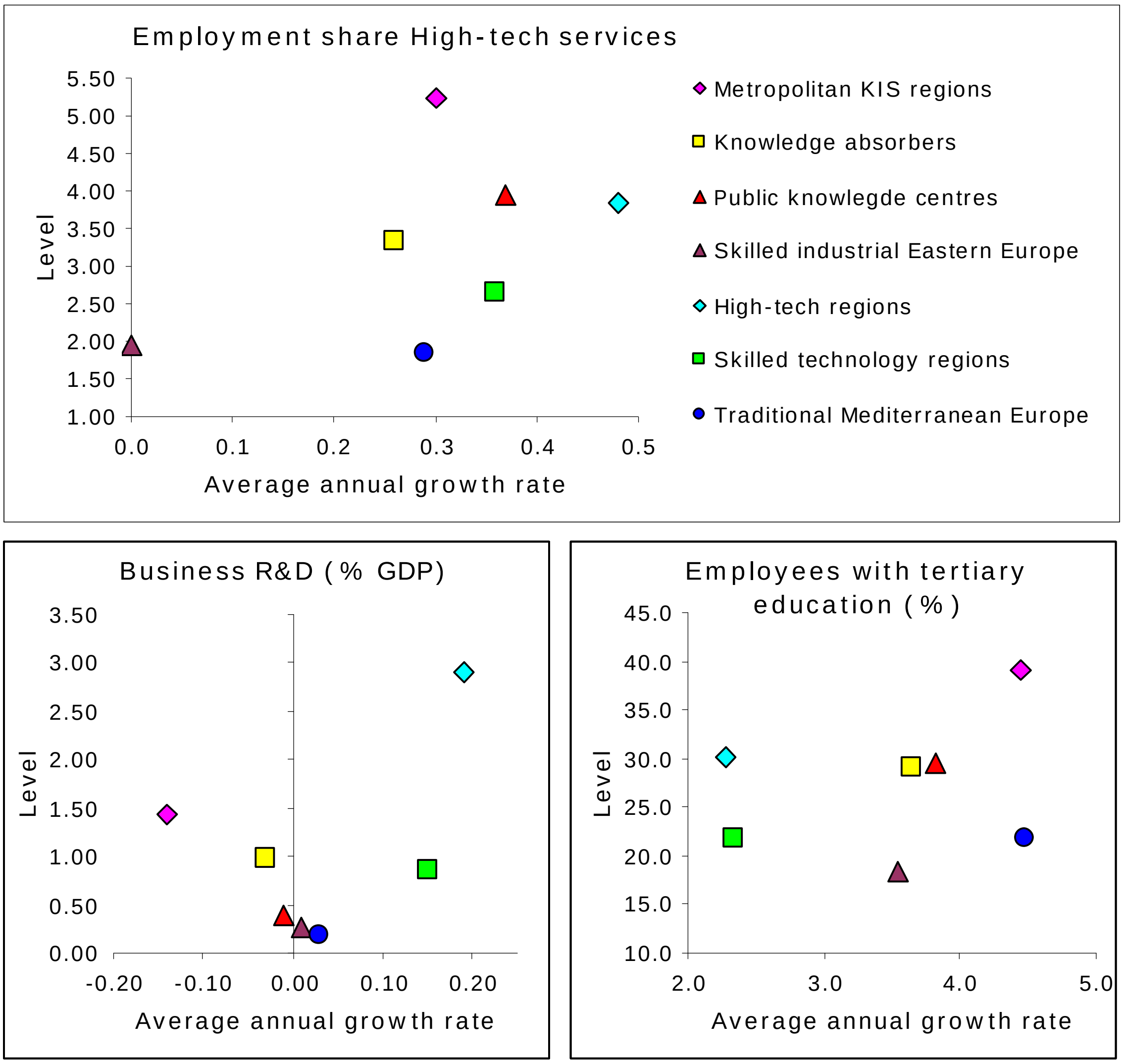
For those knowledge and technology indicators for which divergence is the dominant trend, different types of 'polarisation' can be identified. Regarding the diverging trend for High-tech services, Metropolitan KIS and High-tech type of regions both share a position of 'moving further ahead' (see figure 4.2), 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 4.2 Level and trend per type of region for high-tech services, business R&D and tertiary education



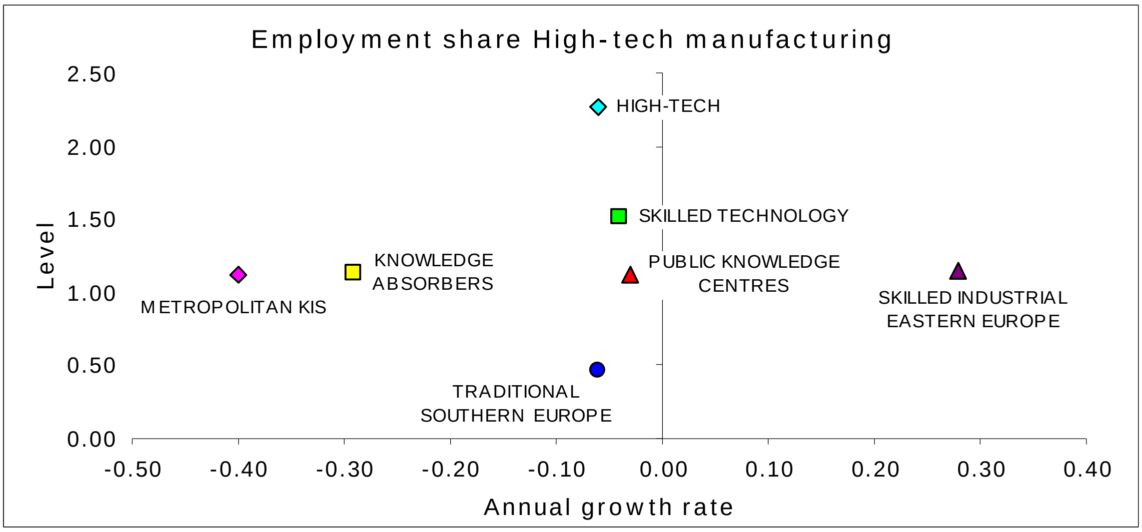
Another explanation for the difference between the spatial trend for patents and for business R&D expenditure could be the shift in the kind of research, for example the increase in R&D expenditure in the high-tech regions could largely occur in software development, which does not lead to a growth in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

Figure 4.3 Level and trend per type of region for the employment share of 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.

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.

Table 4.2 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.

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).

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.

Table 4.3 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.

In order to identify the impact of knowledge variables on unemployment rate, the regions have again 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.

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 5.1.

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' (see table 5.1). 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 5.1 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 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 paragraph 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 5.2).

Table 5.2 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 5.3 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 5.4

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 5.4 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 5.5 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 5.6.

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 5.6: 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 chapter 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. The Tables in Annex summarize the differences in responses to the survey questions for the different types of 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 6.1). 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 6.1 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’ (see Tables in Annex). 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 6.2 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 • 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	Weaknesses • 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 • 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	Threats • 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 6.3). 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 6.3 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 6.4), 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 6.4 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%.

Turning to the results of the survey 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 • Large share of high- and medium-high-tech manufacturing • Strong patenting in metal products and machine tools • Increased Business R&D intensity	Weaknesses • Low increase in tertiary educated • Limited share high-tech services
Opportunities • More co-funding applied R&D and innovation projects • Improve the education system and invest more in Life-long learning • Strengthen government research organizations	Threats • 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 eitgh 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 6.5) 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 6.5 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.

Strengths	Weaknesses
• Productivity in service industries • High university research expenditures as % of total R&D • Increased level of education • Increased patenting	• 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
Opportunities	**Threats**
• 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	• Scarce water resources • Unemployment

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'.

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 chapter 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 spill-overs 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 survery. 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 either 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 study 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.

The results of this study confirm 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’.

The study has also shown that regional innovation policy making has become 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 maximise the benefits of cohesion policy investment in innovation.

References

Aydalot, P. (1986), 'Milieux Innovateurs en Europe', Paris, France: GREMI.

Chesbrough, H. (2003), 'Open Innovation: The New Imperative for Creating and Profiting from Technology', Cambridge, USA: Harvard Business School Press.

Cooke, P. and L. Leydesdorff (2006), 'Regional development in the knowledge based economy: the construction of advantage', Journal of Technology Transfer, 31, 5-15.

Dunnewijk, T., H. Hollanders and R. Wintjes (2008), 'Benchmarking regions in the enlarged Europe: Diversity in knowledge potential and policy options', In: Innovation Policy in Europe; Measurement and strategy, C. Nauwelaers and R. Wintjes (eds.), 2008, Edgar Elgar.

Edquist, C. (ed.) (1997), 'Systems of Innovation: Technologies Institutions and Organizations', London, UK: Pinter.

Foray, D. and B. van Ark (2007) 'Smart specialisation in a truly integrated research area is the key to attracting more R&D to Europe', Expert Group Knowledge for Growth, Policy Brief No. 1, http://ec.europa.eu/invest-in-research/pdf/download_en/policy_brief1.pdf

Hollanders, H., S. Tarantola and A. Loschky (2009), Regional Innovation Scoreboard (RIS) 2009. PRO INNO Europe Paper No. 14.

IPTS (2009), 'The 2009 Report on R&D in ICT in the European Union'. JRC-IPTS, Seville.

Leydesdorff, L. (2006), 'The knowledge-based economy and the triple helix model', in W. Dolfsma and L. Soete (eds), Understanding the Dynamics of a Knowledge Economy, Cheltenham, UK: Edward Elgar.

Lundvall, B. A. (ed.) (1992), 'National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning', London, UK: Pinter.

Morgan, K. (1997), 'The learning region: institutions, innovation and regional renewal', Regional Studies, 31 (5), 491-503.

Nelson, R.R. (ed.) (1993), 'National Innovation Systems: A Comparative Analysis', Oxford, UK: Oxford University Press.

OECD (2009), 'Regions Matter; Economic recovery, innovation and sustainable growth'.

Soete, L. (2008), 'Current Theories on Growth and Development: How to Promote Regional Innovation through Cohesion Policy.'

Soete, L. (2009), Summary of conclusions of the Expert Group on "The Role of Community Research Policy in the Knowledge-Based Economy". http://ec.europa.eu/research/conferences/2009/era2009/speakers/papers/paper_luc_soete.pdf

Annex 1 Regional typology

High-tech regions
DE11 Stuttgart; DE12 Karlsruhe; DE13 Freiburg; DE14 Tübingen; DE21 Oberbayern; DE23 Oberpfalz; DE25 Mittelfranken; DE26 Unterfranken; DE71 Darmstadt; DE91 Braunschweig; DEB3 Rheinhessen-Pfalz; NL41 Noord-Brabant; FI19 Länsi-Suomi; FI1A Pohjois-Suomi; SE12 Östra Mellansverige; SE22 Sydsverige; SE23 Västsverige.

Skilled technology regions
DE22 Niederbayern; DE24 Oberfranken; DE27 Schwaben; DE5 Bremen; DE72 Gießen;DE73 Kassel; DE92 Hannover; DE93 Lüneburg; DE94 Weser-Ems; DEA1 Düsseldorf; DEA3 Münster; DEA4 Detmold; DEA5 Arnsberg; DEB1 Koblenz; DEB2 Trier; DEC Saarland; DED1 Chemnitz; DEF Schleswig-Holstein; DEG Thüringen; FR42 Alsace; FR43 Franche-Comté; ITC1 Piemonte; ITC4 Lombardia; ITD3 Veneto; ITD4 Friuli-Venezia Giulia; ITD5 Emilia-Romagna; ITE2 Umbria; ITE3 Marche; ITF1 Abruzzo; AT11 Burgenland (A); AT12 Niederösterreich; AT21 Kärnten; AT22 Steiermark; AT31 Oberösterreich; AT32 Salzburg; AT33 Tirol; AT34 Vorarlberg; SI Slovenia.

Skilled industrial Eastern EU regions
BG32 Severen tsentralen; BG34 Yugoiztochen; BG42 Yuzhen tsentralen; CZ02 Strední Cechy; CZ03 Jihozápad; CZ04 Severozápad; CZ05 Severovýchod; CZ06 Jihovýchod; CZ07 Strední Morava; CZ08 Moravskoslezsko; EE Estonia; LV Latvia; LT Lithuania; HU21 Közép-Dunántúl; HU22 Nyugat-Dunántúl; HU23 Dél-Dunántúl; HU31 Észak-Magyarország; HU32 Észak-Alföld; HU33 Dél-Alföld; PL11 Lódzkie; PL21 Malopolskie; PL22 Slaskie; PL31 Lubelskie; PL32 Podkarpackie; PL33 Swietokrzyskie; PL34 Podlaskie; PL41 Wielkopolskie; PL42 Zachodniopomorskie; PL43 Lubuskie; PL51 Dolnoslaskie; PL52 Opolskie; PL61 Kujawsko-Pomorskie; PL62 Warminsko-Mazurskie; PL63 Pomorskie; RO11 Nord-Vest; RO12 Centru; RO21 Nord-Est; RO22 Sud-Est; RO31 Sud – Muntenia; RO41 Sud-Vest Oltenia; RO42 Vest; SK02 Západné Slovensko; SK03 Stredné Slovensko; SK04 Východné Slovensko.

Metropolitan knowledge intensive services regions
BE1 Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest; BE24 Prov. Vlaams Brabant; BE31 Prov. Brabant Wallon; DK Denmark; DE3 Berlin; DE6 Hamburg; DEA2 Köln; DED2 Dresden; FR1 Île de France; FR62 Midi-Pyrénées; LU Luxembourg (Grand-Duché); NL11 Groningen; NL31 Utrecht; NL32 Noord-Holland; NL33 Zuid-Holland; AT13 Wien; FI18 Etelä-Suomi; SE11 Stockholm; UKH2 Bedfordshire, Hertfordshire; UKI1 Inner London; UKI2 Outer London; UKJ1 Berkshire, Bucks and Oxfordshire; UKJ2 Surrey, East and West Sussex.

Public knowledge centres
BG31 Severozapaden; BG33 Severoiztochen; BG41 Yugozapaden; CZ01 Praha; DE4 Brandenburg; DE8 Mecklenburg-Vorpommern; DED3 Leipzig; DEE Sachsen-Anhalt; ITD2 Provincia Autonoma Trento; ITE4 Lazio; HU1 Közép-Magyarország; NL13 Drenthe; NL23 Flevoland; PL12 Mazowieckie; RO32 Bucuresti – Ilfov; SK01 Bratislavský kraj.

Traditional Southern regions
GR11 Anatoliki Makedonia, Thraki; GR12 Kentriki Makedonia; GR13 Dytiki Makedonia; GR14 Thessalia; GR21 Ipeiros; GR22 Ionia Nisia; GR23 Dytiki Ellada; GR24 Sterea Ellada; GR25 Peloponnisos; GR41 Voreio Aigaio; GR42 Notio Aigaio; GR43 Kriti; ES11 Galicia; ES12 Principado de Asturias; ES13 Cantabria; ES23 La Rioja; ES41 Castilla y León; ES42 Castilla-la Mancha; ES43 Extremadura; ES52 Comunidad Valenciana; ES53 Illes Balears; ES61 Andalucia; ES62 Región de Murcia; ES7 Canarias (ES); FR83 Corse; ITF2 Molise; ITF3 Campania; ITF4 Puglia; ITF5 Basilicata; ITF6 Calabria; ITG1 Sicilia;

ITG2 Sardegna; CY Cyprus; MT Malta; PT11 Norte; PT15 Algarve; PT16 Centro (PT); PT17 Lisboa; PT18 Alentejo.

Knowledge absorbing regions

BE21 Prov. Antwerpen; BE22 Prov. Limburg (B); BE23 Prov. Oost-Vlaanderen; BE25 Prov. West-Vlaanderen; BE32 Prov. Hainaut; BE33 Prov. Liège; BE34 Prov. Luxembourg (B); BE35 Prov. Namur; IE01 Border, Midlands and Western; IE02 Southern and Eastern; GR3 Attiki; ES21 Pais Vasco;ES22 Comunidad Foral de Navarra;ES24 Aragón;ES3 Comunidad de Madrid;ES51 Cataluña; FR21 Champagne-Ardenne; FR22 Picardie; FR23 Haute-Normandie; FR24 Centre; FR25 Basse-Normandie; FR26 Bourgogne; FR3 Nord - Pas-de-Calais; FR41 Lorraine; FR51 Pays de la Loire; FR52 Bretagne; FR53 Poitou-Charentes; FR61 Aquitaine; FR63 Limousin; FR71 Rhône-Alpes; FR72 Auvergne; FR81 Languedoc-Roussillon; FR82 Provence-Alpes-Côte d'Azur; ITC2 Valle d'Aosta/Vallée d'Aoste; ITC3 Liguria; ITD1 Provincia Autonoma Bolzano-Bozen; ITE1 Toscana; NL12 Friesland (NL); NL21 Overijssel; NL22 Gelderland; NL34 Zeeland; NL42 Limburg (NL); FI13 Itä-Suomi; SE21 Småland med öarna; SE31 Norra Mellansverige; SE32 Mellersta Norrland; SE33 Övre Norrland; UKC1 Tees Valley and Durham; UKC2 Northumberland, Tyne and Wear; UKD1 Cumbria; UKD2 Cheshire; UKD3 Greater Manchester; UKD4 Lancashire; UKD5 Merseyside; UKE1 East Yorkshire and Northern Lincolnshire; UKE2 North Yorkshire; UKE3 South Yorkshire; UKE4 West Yorkshire; UKF1 Derbyshire and Nottinghamshire; UKF2 Leicestershire, Rutland and Northants; UKF3 Lincolnshire; UKG1 Herefordshire, Worcestershire and Warks; UKG2 Shropshire and Staffordshire; UKG3 West Midlands; UKH1 East Anglia; UKH3 Essex; UKJ3 Hampshire and Isle of Wight; UKJ4 Kent; UKK1 Gloucestershire, Wiltshire and Bristol/Bath area; UKK2 Dorset and Somerset; UKK3 Cornwall and Isles of Scilly; UKK4 Devon; UKL1 West Wales and The Valleys; UKL2 East Wales; UKM Scotland; UKN Northern Ireland.

Annex 2 Literature review[4]

2.1 Background and policy context

Polarisation and cohesion

Mapping the innovation performance of European regions shows a polarised view with a core and periphery in terms of innovation potential. Since innovation is important for sustainable growth it is important to gain insights in future regional impact in terms of polarisation and cohesion. Will the spatial concentration of technological change in Europe increase? Would this lead to increased regional disparities, and would this slow down the trend of convergence of the recently joined Member States? Answering such questions is complicated because technological change and innovation, or a knowledge-based economy has many aspects. It includes a variety of activities and a variety of actors (e.g.: industries, universities, students, SMEs and policy makers). 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, e.g. regarding science, innovation, human resources and entrepreneurship. For certain fields of science it would for instance be efficient to increase the integration in the ERA (European Research Area) and concentrate the efforts in a few centres of excellence. Benefiting from economies of scale and agglomeration in such centres might be needed in order to compete on a global scale. Other aspects of knowledge economies, such as education, ICT, life-long learning and high- and medium-high tech manufacturing are more important for absorbing and applying technologies developed elsewhere and therefore play an important role in processes of convergence and catching up. This also implies that regional innovation strategies are 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. There is in other words, a nearly pervasive, across the board reliance on innovation expenditures in Europe to bring about regional growth: in technologically leading regions so as to remain ahead; in peripheral regions so as to catch up.

Regional specialisation within an integrated European knowledge economy

There is more to be said than ranking regions from high to low and there is more to question for the future than the core-periphery model. 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 will 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. R&D expenditure is highly concentrated and even among the good performing Member States there are regions with below EU average performance.

---

[4] Based on the Literature study by Theo Dunnewijk and René Wintjes

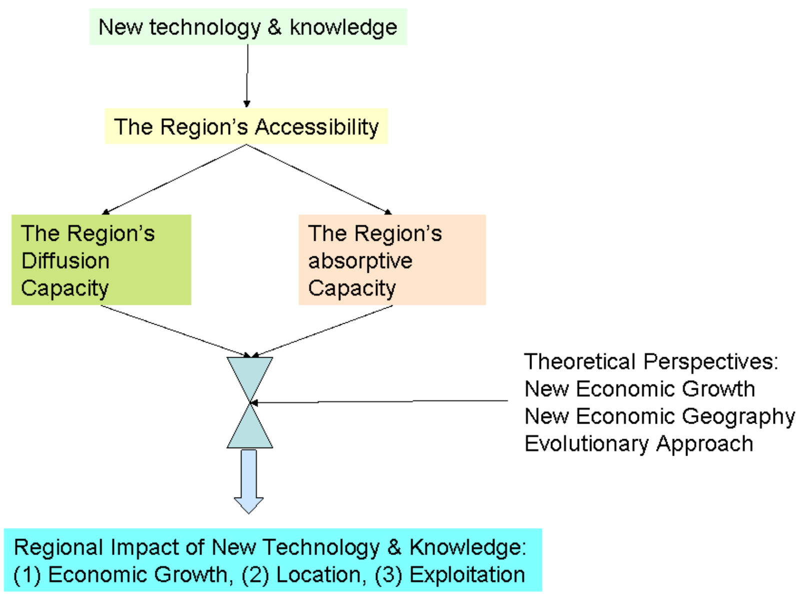
So, even among the R&D intensive regions there is a diversity of types of regional innovation systems. With future progress in the integration of the European Union as one area of research and innovation (ERA) it is likely that the specialisation of different types of regional knowledge economies will 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.

2.2 Insights from theory and empirical work

The regional impact of new technology and knowledge depends on several features of the region. In the first place the region's accessibility determines the exposure of the region to new technologies and the concomitant knowledge. In the second place the region's absorptive capacity as well as its capacity to diffuse (or in other words to internalise new technologies & knowledge and to communicate or trade it with other actors) are very relevant features.

This process of emergence and internalisation of new knowledge has been investigated in the literature from at least three perspectives: New Growth Theory, New Economic Geography and Evolutionary Economic Approach. Old growth theories stress the endemic diffusion of knowledge, rationality of the actors under a regime of full information about the future. New theories of this kind stress the specific role of knowledge, which allows actors "to stand on the shoulders of giants". Especially in the information age knowledge is "everywhere" and once it is understood it can be applied in practice. New economic geography introduced transaction costs (like transport costs) as an important driver for allocation of economic activity, while the evolutionary approach admits that path dependent and dynamic developments limit the room to manoeuvre for the actors who after all are not fully informed about the future too.

Figure 1 Overview



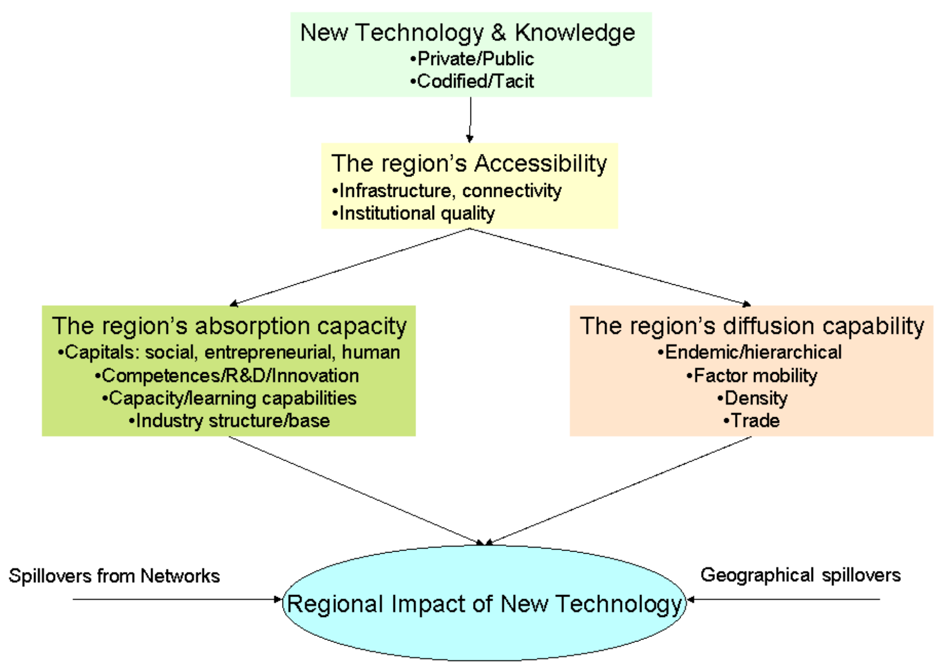
Our focus here is on the impact of new technology and new knowledge (knowledge for short in the sequel) in the regions. Especially (1) the impact of knowledge on regional economic growth, (2) how knowledge affects the location choice for economic activity and (3) how knowledge is exploited at the regional level. To answer these three questions one need to know the region's position and attitude towards technology and knowledge in general. This attitude is determined by the accessibility of the region and by two other features: how knowledge diffuses regionally and how technology can be absorbed by the region. Schematically this framework is given in Figure 1.

New technology and knowledge "arrives" in the region then the region's accessibility determines the lag between emergence and arrival. The region's absorption capacity determines what is understood from this knowledge and its diffusion capacity how fast it will spread before it will becomes endemic in the region. As a result both the region's absorption capacity and its capacity to diffuse knowledge determine the impact of knowledge. On their turn the three theoretical perspectives each on its own way determine how the impact of the new technology and knowledge will be perceived and assessed.

2.2.1 Accessibility, absorption and diffusion of knowledge in the region

A pictorial imagination of how new technology impacts the region is given in Figure 2. At the top of the figure new technology is equated with knowledge. If we assume that old technology is what people know all about and new technology is what just a few people know about, then we can assume that this new technology, if it is useful, gradually will become known to, and used by an increasing number of people. Eventually new technology will firstly reach the broad public that lives in the most accessible regions; regions that are well connected to the world, that have excellent telecommunication networks and other physical and institutional infrastructures and/or are networked with the region where this new technology came from.

Figure 2 Overview of the regional impact of New Technology & Knowledge



New Technology & Knowledge

Whether it is new technology or new knowledge the most accessible regions will have an advantage by knowing or understanding this new technology or new knowledge earlier and better than less accessible regions. Knowledge eventually is mostly theoretical, scientific or practical in nature and highly technologically dependent. Knowledge thus is an umbrella concept like e.g. the knowledge based economy – which is driven by new information and communication technologies. Cities are generally regarded as more accessible than the country side and codified knowledge is assumed to be more accessible than embodied or tacit knowledge.

The Region's Accessibility

The region's accessibility with regard to knowledge is dependent on the local infrastructure and connectivity with the world and the quality of the regional governance. Thus it is the density and the quality of the information flows that are regarded as crucial for the regions' accessibility. In this sense cities are more accessible than villages and while proximity to markets is also an important element in this respect (Poelhekke and Van Der Ploeg, 2008). Accessibility is also dependent on the incidence of knowledge institutes and existing networks; R&D and innovation activities further reinforce the position of some locations above others, we therefore take aboard these factors on the account of the regions' absorptive capacity.

Knowledge can be distinguished into public and private knowledge, while public knowledge is –in principle- widely available and easy to access (Senker, 1995) private knowledge is appropriated otherwise: by means of licenses and patents. Codified knowledge is easier to transfer compared with tacit knowledge, tacit knowledge needs special treatment and face to face communication before it can be transferred and understood by third parties (Cowan, David and Foray, 2006, Godin 2006, Asheim and Gertler, 2005, Bercovitz and Feldman, 2005, Foray and Lundvall, 1996 and Nelson and Winter, 1982).

An assumption of the old theories of economic growth was that all regions have equal access to knowledge; but this assumption turned out to be untenable; it has been rejected over and over again by the empirical literature. Instead we can safely assume that knowledge essentially is concentrated in some regions (Vernon, 1966) due to path dependent and cumulative reasons (Nelson and Winter, 1982). These differences in the allocation of knowledge cause international trade which is a vehicle for diffusion of the knowledge that comes and is incorporated in the goods and services traded.

A large branch of the (evolutionary) literature on technological change addresses firm behaviour and inter-firm exchange and other linkages between firms and their environment as Moulaert and Sekia (2003) have pointed out in their overview on territorial innovation. Many theoretical studies on technological change are conceptual evolutionary studies and use as illustrations in-depth case studies. The more recent concepts emphasize technology and knowledge as well as the importance of institutions, making up a technological system. A technological system is a system with several actors: firms, organisations, policy bodies, venture capitalists etc. (Carlsson et al. 2002). With concepts such as 'Regional Innovation Systems' (Rosenfeld, 1997; Cooke, 1998); 'knowledge-based economy' (Cooke and Leydesdorff 2006), 'Open Innovation' (Chesbrough, 2003), and 'Triple-helix' (Leydesdorff, 2006) importance is given to both public and private research. University, industry and government together form the Triple Helix model, but, we question to what extent these aspects of innovation systems are co-agglomerated in the same regions. Institutional differences are present in Europe in many features, migration within and beyond the borders of the region, the country, the large national differences in the price of dwellings, the many languages spoken in the EU, the large cultural differences, all these features are limiting mobility of labour within the common market. It is therefore quite possible that EU doesn't share a common production technology limiting labour mobility any further (Rodriquez-Pose, 1998).

Case studies of the type of Saxenian's Silicon Valley study –among others- show the institutional complexity of a regional high-tech cluster. In these regions it is the subtle combination of many elements: highly mobile skilled labour (Zellner, 2003, Park 2004) suppliers, a variety of interacting institutions like the university, the trade associations, the business organisations, business services and venture capital firms that make the difference. Although the incidence of these institutions is directly measurable, their quality is not. Audretsch and Keilbach (2004) touch upon this problem and assume that "entrepreneurship capital" is included in the broad spectrum of local institutions, policies, history and social and cultural traditions. They conclude that public policies that stimulate entrepreneurship improve economic performance of the region. In the same sense shows Beugelsdijk (2007) that national institutions – and the national innovation system[5]- are all relevant for the entrepreneurial culture in the region. Tabellini (2005) confirms that early historical institutions and culture have shaped current institutions while current regional economic performance is crucially dependent on current regional institutions, taking into account the contribution of national institutions.

In conclusion, there are different types of approaches leading to different technological systems and there is very much variation in interaction between the actors. This taken together determines the accessibility of a region for new technology and knowledge and is an important factor for its absorptive capacity.

The Region's Absorptive Capacity

The ability of a regional economy to absorb external information and resources has been called its absorptive capacity (Adler, 1965; Cohen and Levinthal, 1990). Among other things it depends on the level of skills, equipment and professional networks available in the regions as well as the availability of knowledge intensive services and the incidence of outsourcing. Knowledge spillovers from nearby technological opportunities and interdependence among competitors cause and reinforce further the absorptive capacity (Abramovitz, 1986; Cohen and Levinthal, 1989; Antonelli, 1998). The absorption of "local" tacit knowledge is greatly facilitated by the relations to local partners (Gertler, 2003) and dynamic capabilities which are essential for successful appropriation of knowledge in firms (Teece and Pisano, 1994).The absorptive capacity of a region thus determines its potential responsiveness to new things. The actual adoption of new technology however also depends on the level of human capital, while the formation of human capital is driven by the application of new technologies; it is the self reinforcing loophole of learning by doing that is at work here (Arrow, 1962), apart from explicit inventing or discovering in R&D processes (Audretsch and Feldman, 1996; Audretsch 1998). In general this process is thought to be highly cumulative by many authors.

The Region's Diffusion Capacity

The diffusion of knowledge cannot be strictly separated from the absorptive capacity of a regional innovation system; in fact they go hand in hand. Innovation systems involve the creation, diffusion and use of knowledge (Carlson cs., 2002). Knowledge can be diffused endemically (a typical old theories assumption) or hierarchically (Caniëls, 2002) and especially the linkages between industrial activities and R&D at the knowledge institutes feature prominently in this process. Also international trade, the mobility of professionals over the regions and technological fields impacts the diffusion of knowledge locally.

[5] This is akin to what above was called a technological system.

The generation, diffusion and application of knowledge are also impacted by the character of national and regional innovation systems (Patel and Pavitt, 1994; Nelson, 1993 and Lundvall, 1992). These systems -as explained above- incorporate the institutions, incentives and competences that are present in a region, it is in other words an implicit recognition of the importance of tacit knowledge the diffusion of which is strongly impacted by distance to knowledge in other regions (Pavitt, 2002).

While explaining accessibility, absorption and diffusion of knowledge we touched upon three schools of economic theory, in the next paragraph these perspectives are explained more systematically and their assumptions highlighted.

2.2.2 Three theories

With the appropriate theories we like to disentangle the logic of how technology and innovation impacts society at the regional level. It is well known that “technological change and innovation” lies at the heart of economic growth and regional development. And although many of these theories are static in character it is certainly not a static phenomenon. The relationship between technological change and economic growth and development can be analyzed from a variety of theoretical perspectives (Verspagen 2004). We highlight three perspectives.

The first perspective is firmly based on the neo-classical economic approach to technological change and innovation. This perspective stresses intentional and rational actions of people that are driven by market forces. Knowledge is an important instrument to exert power over others for personal benefit. Once new knowledge has been produced it can be sold and be used over and over again, leading to what has been called “endogenous growth”, increasing productivity and standards of living. In this endogenous, but linear concept of technological change presented by new growth theory the accumulation of knowledge in human capital is the most important carrier of growth (Romer, 1986) consequently more R&D and innovation is good for every region. As in traditional economic theory: factor movements (migration of labour or capital) or interregional trade can be seen as diffusion processes that will lead to convergence, since knowledge is embodied in people, goods and capital.

But, since economic development and innovation activities have always shown a strong geographical concentrated and unequally dispersed geographical pattern, it is very relevant to discuss theories which specifically address spatial issues and geographical differences. In economic geography core-periphery thinking has always been the dominant strand, with emphasising different advantages of agglomeration and urbanisation. The oldest work emphasized factors such as transport costs, scale effects and proximity to markets (e.g.: von Thünen, 1826, Christaller 1933) which has lead to a hierarchical urban system (Pred 1966), which on its turn is enforced by the uneven spatial distribution of political power (e.g. central government) and economic power (e.g. corporate headquarters), while peripheral regions may suffer from a cumulative causation of low development (Myrdal, 1957). Innovation is not the only factor that can lead to economic growth, but since innovation and knowledge flows are also found to be spatially concentrated, it has the potential to create spatial patterns in which high and low development are separated geographically (e.g., Storper and Walker 1989). Krugman (1991) has incorporated these agglomeration advantages in formal neo-classical economic theory which is referred to as new economic geography. Based on transport-cost, spatial increasing returns and monopolistic competition, increasing market integration will lead to divergence rather than convergence (e.g., Krugman 1993).

An evolutionary approach does not deny that processes of catching-up may occur, but they reject the idea that this can be taken as universal and irreversible phenomenon. According to Abramovitz (1986) the process of convergence[6] could refer to some countries only, while others could 'forge ahead' or 'fall behind'. The evolutionary approach acknowledges both diverging and converging processes but they emphasise the importance of a broad range of enabling and restricting conditions. The link between innovation and growth is not seen merely as a linear process: more R&D may not be enough. Whereas in the neoclassical approaches regions are treated as 'neutral spaces' and geographical patterns are explained by the behaviour of the perfectly informed 'rational economic agent'. Evolutionary economists argue that 'the explanation to why something exists intimately rests on how it became what it is' (Dosi, 1997). Or in the words of Nelson and Winter (1982) progress is achieved by practices that have a certain amount of routine, while the criteria to assess progress must be stable while a lot is gained by unplanned experiments (Nelson, 2008). Thus, economic growth is seen as a historical process that cannot be understood without taking into account historical specificity (as the neo-classical approaches do) (Atkinson and Stiglitz, 1969).

One of the central mechanisms that make technology a potentially diverging factor is the property that knowledge itself is an important factor in producing knowledge (Verspagen 2008; Dosi 1988). Thus, those (firms, regions, countries) who already possess an advantageous position in generating technological change for growth, are likely to remain in a good position: Knowledge is cumulative and characterized by (dynamic) increasing returns. This phenomenon is potentially counteracted by another characteristic of technology and knowledge, i.e., that it is a non-rival good that may spill over to others than the ones who originally introduce an innovation. In other words, technology may be imitated at lower costs than at which it is introduced. This is a great potential source of welfare, since it greatly increases the potential pay-off of technological change without proportionally increasing the costs of it. Thus, convergence by means of the diffusion of knowledge will raise both the general level of welfare in the economy, and increase cohesion.

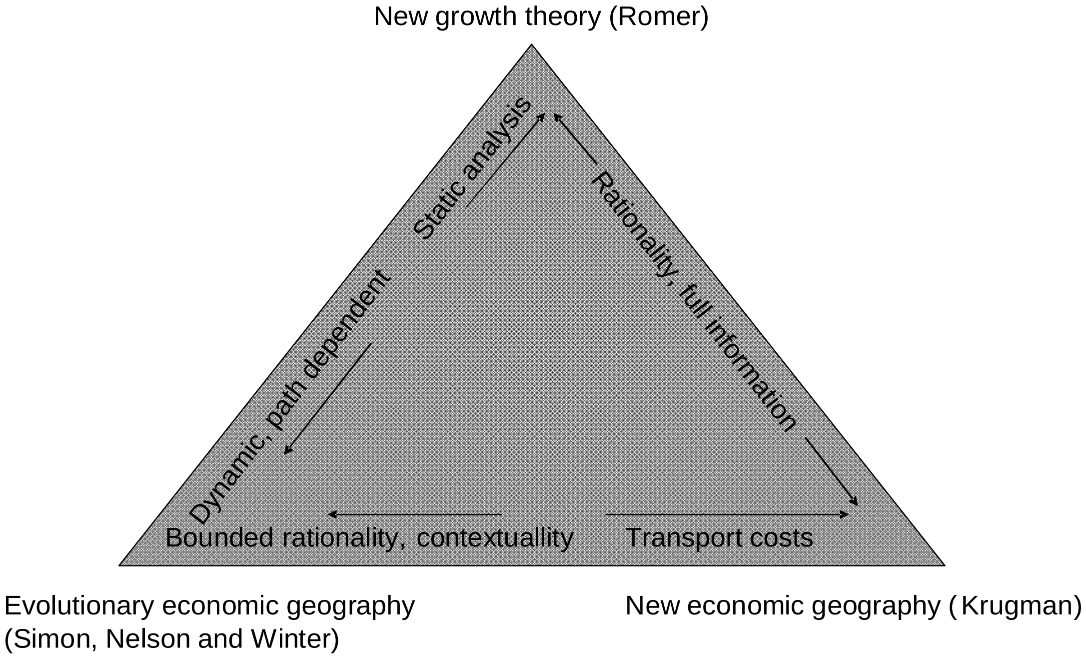
Models of location choice are to be found in the economic literature in the 'new economic geography'. This branch of economic theory introduced by Krugman, (1991) and reintroduced by Fujita, Krugman & Venables (1999) is based on trade theory and on a long tradition of spatial economic analysis by Marshall; Jacobs (1970, 1986); Arrow (1962) and Romer (1986). Increasing returns is the key assumption in this school of thought. New insights were added by Ottaviano & Thisse (2003). Basically these new insights learn that interaction between increasing returns, factor mobility and transportation costs can be applied to urban, regional as well as international economics. Within this framework the local impact of a technology is multidimensional and cascaded: it might affect economic growth which impacts on its turn social and economic equity and the environment. Mobility of factors of production crucially depends on the quality of local institutions, human and social capital and the local endowments. New economic geography taught us that trade theories and location theories merge seamlessly. However the core periphery typology distinguished is rather meagre, while in practice we are interested in a richer typology.

To summarize (see Figure 3) new growth theory builds upon the foundations of neo-classical economics (rational men, full information, a unique equilibrium and context irrelevance) and labels human capital and knowledge as the main drivers of technological change. New economic geography is also a neo-classical theory but the addition here is the explanation of the spatial allocation of economic activity by means of transaction costs and differences in factor prices, dissolving the neutral space of neo-

[6] Convergence i.e. as time goes by differences in economic development between regions will diminish (weak convergence) or even disappear (strong convergence), see also paragraph 2.2.3.

classical approaches. Evolutionary economic geography differs from both approaches because it explicitly takes into account the context (the local institutions and culture and thus path-dependency leading to multiple spatial allocations). Fully informed (neo-classical) actors are replaced by actors that process imperfect information, while they are bounded rational instead of full.

Figure 3 The three major economic theories



The consequences in terms of geographic allocation of economic activity are quite different in these three theoretical perspectives: new growth theory cannot explain uneven regional allocations, while new economic geography comes up with a core–periphery allocation. The evolutionary economic geography however is more suitable to understand why other types of allocations occur, although the drivers of these allocations are a complex of factors: local infrastructure, externalities, especially in skills and local labour markets, specialised services and not least, mutual trust and personal relationships (have) contributed greatly to flourishing of the regions (Freeman, 1991).

The literature incorporated in this review has been selected as far as it elucidates or leads to a better understanding of the following three questions:

Question 1. How does technological change and innovation impact sustainable growth at the regional level? Whether growth is sustainable depends on how efficiency, equity (spatial, interpersonal and intergenerational) and the environment are affected. (The growth question)

Question 2. How does technological and innovation impact spatial disparity? (The location question)

Question 3. Is the regional potential to exploit technological change and innovation path dependent? And if so, which are the key factors determining such path dependency? (The exploitation question)

2.2.4 The three questions elucidated by the literature

In this paragraph we depart from three focussing questions how knowledge impacts: economic growth, location and exploitation.

The growth question

Economic growth is better understood by distinguishing not only physical labour and capital but also human capital and knowledge. As a matter of fact future technology is embedded in past and present knowledge and the accompanying human capital. A traditional assumption in the neoclassical literature – of which the new growth theory is a part – is to perceive knowledge as being freely available. Despite its public good properties, the diffusion of knowledge does not happen "automatically" or without costs and efforts. Therefore regional patterns as well as barriers to the diffusion feature prominently in explaining the differentials in welfare between regions (Döring and Schnellenbach, 2006; Glaeser et al., 1992; Griliches, 1992; Grossman and Helpman, 1991; and Barro, 1991). These – and many more – authors emphasise the relevance of positive static and dynamic externalities - the so-called knowledge spillovers - causing positive returns to scale. Essentially these externalities result from human interaction in the region, driving down the unit costs of production; consolidating sustained economic growth in the region for some time.

However economic growth and development is not a smooth process. Catching up, forging ahead and falling behind still is reality as e.g. Fagerberg, Srholec and Knell (2007) has shown. They explain economic growth in 90 countries during 1980 – 2002 as driven by the competitiveness of countries. Competitiveness is – according to these authors- a three pronged phenomenon and its dimensions are: technology, capacity and demand. Their conclusion is that the differences in competitiveness between countries are large: advanced countries perform much better than the rest of the world, despite that capacity is less unequal distributed and especially technology is a source of continuing divergence among the countries of the world.

For EU regions Cuaresma, Doppelhofer and Feldkircher (2008) analysed the nature of economic growth and conclude that (conditional) income convergence between 1995 and 2005 is a reality in 225 European regions. Convergence is present in Western European Countries, taking account of spatial effect based on distance[7], while capital regions perform better than other regions, human capital, size of infrastructure and population growth in neighbouring regions matters for regional economic growth.

Brauniger and Niebuhr (2005) combine New Economic Geography and New Growth theories and use this framework and a topology of regions to better understand economic development of the regions during 1980 – 2002. Global effects are driven by patents and technological knowledge, while local spillovers from R&D and tacit knowledge drive the regional developments.

European regions do not converge and due to inward migration many regions remained trapped into a high unemployment and a low GDP growth situation. (Verspagen and Fagerberg, 2002; Fagerberg, Verspagen and Caniëls, 1997) Considering the kinds of economic structure (as being modern vs. traditional) with local reallocation frictions,

---

[7] Airline distances corrected with a negative power function with a benchmark value of 1 and alternative weights of 2, 3 and 4, however alternate weights do not change the qualitative conclusions.

R&D efforts, credit support are found to be drivers of economic growth (i.e. Productivity growth). Although the impact is context dependent: peripheral, urban and growth poles show different developments.

Cowan and Jonard, 2003, emphasise that spillovers in knowledge diffusion are based on social networks. Sterlachinni, 2008 and Asheim and Gertler, 2005, Maurseth and Verspagen 2002, state that knowledge spillovers and tacit knowledge are related, tacit knowledge is fostered by geographical proximity which crucially depend on quality of local interactions between government, business and education.

Capitals: social, entrepreneurial, human
Audretsch, Dohse and Niebuhr (2008) investigate the determinants of entrepreneurial activity in regions for the period 1998-2005 in Germany, using their “spillover theory of entrepreneurship”. They focus on the role of the regional environment, knowledge and cultural diversity. They assume and confirm that knowledge and diversity have a positive impact on firm birth. While sectoral diversity tends to dampen new firm foundation, cultural diversity has a positive and highly significant impact on technology oriented start-ups. Therefore they conclude that regions characterized by a high level of knowledge and cultural diversity form an ideal breeding ground for technology oriented start-ups.

Audretsch & Keilbach (2004) in their work add entrepreneurial capital to the neoclassical production function. For 327 West German Regions during 1989-1992 they apply spatial autocorrelation and found out that a 1% increase in entrepreneurial capital[8] matters four times more for labour productivity than a 1% increase in R&D.

However generating knowledge and human capital are necessary conditions for economic growth, it is not sufficient, because policies are needed to arrive at the necessary focus for conjuring up spillovers.

Social capital is often seen as a necessary addition to the “production function” explanation of economic performance (i.e. in the explanation of Total Factor Productivity). It features as “entrepreneurship capital” and is seen as a specific kind of social capital that generates start-ups of new enterprises (Audretsch and Keilbach, 2004). In this perspective the quantitative impact of social capital is always measured with proxies for entrepreneurship capital (e.g. self employed as a ratio of total employment). Other approaches like Martin & Sunley (2006) and Oughton, Lanadabase and Morgan (2002) include (the development of) social capital in the development of locally specific economic and regulatory institutions, social infrastructures and traditions, which embrace the conditions for local economic activity. In the more general macroeconomic literature social capital enhances physical capital in the sense that a broad concept of capital produces more output (See Barro and Sala-i-Martin, 1990).

In the course of time the neo-classical approach was augmented by more types of inputs. It started with labour and capital. However the combination of these two factors of production could not explain the technological change (in particular total productivity growth) encountered in practice. Therefore an additional factor of production factor was found in “knowledge”. When technological change still was hard to explain, some authors discovered “entrepreneurial capital” as a fourth factor of production (Acs et al., 2004). Entrepreneurial capital is the filter that selects a useful combination of available technology and local (institutional) characteristics. “It is the ability of a region to convert public knowledge into ‘useful’ economic knowledge relies on its availability of

8 This has been approximated by the number of startups in a region relative to its population, or the propensity of the inhabitants to start a new company.

would-be and effective entrepreneurs, which in turn is fostered by a socio-economic environment favourable to new business activities" (Sterlacchini, 2008).

In a market economy human capital formation takes place as a response to market opportunities and its formation is often seen as one of the factors that drive club convergence (see e.g. Canova, 2004; Galor, 1996). The accumulation of these two kind of capital are important in the process of catching up in Europe apart from the necessary conditions as macroeconomic stability and the functioning of the markets, specially capital markets and public infrastructure (Basile, 2009). Human capital is subjective knowledge that has been accumulated over the generations and when human capital formation is concentrated in agglomerations (Glaeser et al. 1992) it is a source of polarisation (Döring and Schnellenbach, 2006).

Measuring human capital and its effects learns that human capital can be measured with several proxies: firstly by mean years of schooling in the population aged 25 and over (Barro and Lee, 2000), secondly by learning by doing and the accompanying R&D activities, thirdly by the ratio of highly educated to the total educated population (Cuaresma cs. 2008), fourthly by learning activities as life long learning, fifthly by the number of university students present in the region (Cheshire and Magrini, 2000).

The output elasticity of human capital (measured with number of researchers) is estimated as 0.12 by Bode (2001) and for the impact of investments in human capital on local GDP between 0.015 and 0.025 by Ederveen cs. (2002).

If human capital increases 10% (measured with the share of high educated in working age population) GDP increases on average 0.6% (Cuaresema et al., 2008). With regard to human capital formation they show that Central and Eastern Europe and Portugal strongly catch up with other EU regions, while it has the largest impact in the core regions as the English and the Nordic regions.

Finally, using spatial econometrics analysis Eckey, Kosfeld and Stock, (2000) found that physical and human capital drives regional growth. While Eckey and Türk, (2006) assert that investment in education and human capital have a great effect on regional growth (see also Canova, 2004; Martin, 1999).

Sterlachinni (2008) investigates the relationship between knowledge and human capital[9] on the one hand and economic growth on the other in European regions. He asserts that geographical dispersion (i.e. disparities in regional growth) cannot be ascribed to different knowledge and human capital endowments in the south of Europe, but in the north of Europe it can. Therefore one has to take into account national characteristics like the National Innovation Systems before assessing the impact of human capital on economic growth. A conflicting conclusion has been drawn by Poelhekken and Van der Ploeg, 2008: human capital seems to be important for modestly developing countries.

Human capital externalities (see e.g. Head and Mayer, 2006) are generally seen as the drivers of a spatial wage structure (Brakman et al. 2006). On the national level Kneller (2004) provides an interesting study about the manufacturing sector in 12 OECD countries, during (1970-1990) as far as human capital's role is concerned. He investigates whether the effect of frontier technology on domestic productivity varies according to absorptive capacity and physical distance from the source of new ideas. The frontier effect –he found– is increasing in the level of human capital and decreasing in physical distance.

[9] Sterlachinni (2008) uses the share of the adult population (aged 25 to 65) in a region that attained tertiary education (i.e. ISCED97 codes 5 and 6) as a proxy for human capital.

On spillovers
Caniëls found that knowledge spillovers are regionally bounded and only play a role within a country. Furthermore GDP per capita is driven by knowledge spillovers, knowledge generation and learning capacity, while Bode (2001) found out that knowledge spillovers are based on the size of employees engaged in R&D.

The way these knowledge spillovers materialise can be found in the theoretical literature as a- priori theories. Apart from spillovers due to a high density of knowledge produced at a university in a region, international trade is an often mentioned source of knowledge spillovers. Internationalisation of production, FDI or in general the mobility of factors of production are the vehicles for growth in this case. However location choice depends among other things also on the contextual factors like the absorptive capacity of a region. This absorptive capacity is defined - according to the literature in the evolutionary tradition - as the capacity to adopt new technology and depends highly on human capital and institutional quality and here we have distinctive competences of a region.

The location question
Fragmentation of production, information technologies and the reduction in transaction costs in general makes it easier to reconsider the choice where to locate new economic activity. Location choice today takes place in a world characterised by the fragmentation of the value chain, Baghwati (1984); Krugman (1996); Arndt and Kierzkowski (2001). The idea of 'slicing the value chain' and 'integration of trade and the disintegration of production in the global economy' that takes place is borrowed from Krugman (1996) and Feenstra (1998). This process gave international trade an enormous boost: International trade multiplied 18-fold from the 1950's while Foreign Direct investment multiplied 25-fold and World production quadrupled.

Trade is seen as a major source of knowledge spillovers (Grossman and Helpman 1994; Coe and Helpman, 1995, Keller, 2002) that materialises locally. These knowledge spillovers are an important source of technological change and are to be found in locations were firms cluster. In this dynamic world supported by information technology, location choices are made very frequently and are based on the broad and specific comparative advantages of regions and these location decisions impact or ignore the regions deeply.

The question of the best location to settle is often answered using discrete choice models (Malecki, 1980 and 1981). Also proximity in user–producer interaction between partners, which characterizes new technologies, is a common factor. Therefore the level of knowledge currently available and the level of knowledge to be produced in the future in the region is an important factor that determines the so-called agglomeration force leading to geographical concentration of innovation and new technologies (see Feldman and Audretsch, 2005, Head and Mayer, 2006, Devereux et al., 2003 and Crozet et al., 2003).

The exploitation question
Comparative (competitive) advantages of a region are largely based on the ability to exploit unique competences and resources (Asheim and Coenen, 2006). A Schumpeterian view is that innovation, entrepreneurship and economic growth are linked by the exploitation of opportunities in the economy. Economic performance surely is impacted by an entrepreneurial culture (Freeman, 1976). Entrepreneurship is seen in the literature as the endogenous response to opportunities created but not exploited by the incumbent firms. Entrepreneurship on the personal level is a matter of attitude and is highly impacted by local culture (Beugelsdijk, 2007).

Path dependent developments can be in the way of exploiting the opportunities and they don't fit very well into the framework of neo classical economics. In this branch of economics only processes that have no memory (i.e. ergodic processes) lead in the end to a unique allocation of production and an economy in equilibrium in which the allocation is supported by competitive prices. In its essence path dependency refers to the opposite of "seizing the moment" due to either technological lock-in effects (as an evolutionary economist like David asserts) or dynamic increasing returns (as an economic geographer like Arthur asserts) or institutional hysteresis (as an institutional economist like North asserts).

Path dependent and /or tacit resources make up entrepreneurial capabilities. The phenomenon of path dependency is especially encountered and assumed in case studies, in econometric studies path dependency is assumed to be the reason for large constant in equations. If the constant in an equation – within the knowledge production function approach - explaining e.g. the number of patents or the level of productivity is large it is often assumed that path dependent development is the main reason (Fritsch, 2002). When the constant is relatively low this can be expected for relatively new industries or an industry that follows a new technological paradigm. In this case the relevant stock of old knowledge is relatively small hence the past determines the entrepreneurial regime, but only for a part Winter (1984); Audretsch (1995); Döring and Schnellenbach (2006); Caniëls (2000); Dosi (1988).

Focussing on what can be said about path dependency is that the creation of a high quality national (or regional) innovation system takes a long time and "... local infrastructure, externalities, especially in skills and local labour markets, specialised services and not least, mutual trust and personal relationships have contributed greatly to flourishing regions" Freeman, (1995). This furniture cannot be installed at once in a certain region, so yes indeed from a theoretical perspective there is a lot of path dependency related to innovation systems and policies.

Entrepreneurship seeks opportunities to exploit novel ideas establishing path creation, while path dependent developments exploit knowledge already gained (Garud and Karnoe, 2000).

In conclusion regions are largely considered as path dependent creations and only conscious identity building and visionary actions can drive regions into other roads and building and reinforcing regional identity, Castells, (1997). To avoid the dangers path dependent developments and lock-in Harmaakorpi and Uotila, (2006) devised the so-called Regional Development Platform method which is a tool for developing regional innovation systems. The system helps to find regional potentials to build the future competitive advantage of the region.

2.2.5 Spatial typologies of regions

Markusen (1996) and Storper (1995), among others provided typologies of regional production systems based on a historical interpretation of the production conditions in artisanal, interpersonal communities, mass production, lean production (flexible mass production) configurations. Storper, claims that technology coalitions and foundations give some regions a competitive edge above others. Therefore configurations based on internal vs. external orientation are preferred: like hub-spoke, satellite platform, and state anchored configurations are likely. Institutions matter very much here especially with regard to the governance dimension like in Cheshire's and Magrini's (2002) functional regions.

The concept of specialised or homogeneous regions - also called Marshallian regions (originally Marshallian Industrial Districts or MID) – is critized by Markusen with arguments that they do not account for especially the linkages between small and medium sized enterprises and the larger ones within and beyond the border of the district. MID's are also assumed to be rather specialised and not conscious of the cooperation among the members. It is the concerted effort to cooperate that makes the difference between the districts.

On the other hand heterogenous regions or Jacobian regions exploit diversity or economies of scope (Jacobs, 1970 and 1986). In these regions firms do not compete so much with each other facilitating cooperation.

Criticising the one-size-fits-all reasoning, Tödtling and Trippl (2005) have drawn on a conceptual framework (a la Nauwelaers and Wintjes, 2003) describing different policy needs for 3 hypothetical types of EU regions: institutional thin, restructuring old industrial and fragmented metropolitan regions.

Other more complex typologies are based either on transaction costs or technological characteristics of regions are three pronged indeed and especially those of Iammarino and McCann (2006). These authors distinguish three types: (1) pure agglomeration, (2) industrial complex and (3) social networks. This combined transaction cost and evolutionary approach leads according to these authors to the following three types of clusters:

- Pure agglomeration clusters (regions) are urban diversified cluster with Jacobs externalities, knowledge is mainly codified and explicit. The clusters that consist of atomistic firms, with non-identifiable and fragmented relations, the cluster is open for new entrants, but location at arms length is necessary,

- Industrial complex (a la Cooke, 2001) is a local or regional cluster with cumulative learning from in-house research focussed on specific applications, dominated by large incumbents. The cluster consists of large and small firms that are identifiable, membership is closed and the members buy and sell goods and services within intermediate relations.

- Social networks (a la Granovetter, 1985, 1991, 1992 and Alchian, 1957) consist of firms that are variable in size and trust, loyalty and joint ventures characterise the relations between the members. Membership is partially open and focussed on generic and non systemic knowledge produced by non-members (e.g. public knowledge by academic research) and based on historical ties and experience, location is not necessary per se.

A typology of countries that is based on data characteristics – using a regression tree algorithm (Breiman et al., 1984) - is given by Durlauf and Johnson, (1995). This is a non-parametric method to identify multiple data regimes from a set of control variables, allowing for multidimensional data splits. Durlauf and Johnson (1995) apply this method to their data on GDP per capita and literacy rate and arrive at a typology that combines (high/low/intermediate) GDP per capita and literacy rates.

Another typology based on factor analysis is given in Dunnewijk cs. (2008). The typology using this method becomes richer facilitating the capacity to adopt technologies of a certain kind.

2.2.6 Summary and Conclusions

Summary

New technology brings new knowledge to the region. It is the regions accessibility, its capacity to absorb and diffuse this knowledge that determines economic growth and prosperity. New technology brings also new possibilities to exploit the knowledge that comes with it. New ventures based on this knowledge settle wherever the surroundings facilitate this exploitation best.

Accessibility, absorption and diffusion are dependent on the connectivity of (and within) the regions, its capital and competences, its mobility and quality of the factors of production and last but not least what it can learn from other neighbouring regions or from being part of a network.

Knowledge is essentially unevenly spread over the regions due to path dependent and cumulative reasons. Institutional factors determine the quality of a technological system in the regions. Such a system is made up of firms, organisations, policy bodies and venture capitalists in the presence of capital: physical, human as well as entrepreneurial.

Knowledge is partly explicit or codified partly tacit or hidden. It turns out that codified knowledge can travel over long distances but tacit knowledge essentially is local in character and needs human interaction and proximity. Relations to local partners and dynamic capabilities determine potential responsiveness to new knowledge. Human capital is another necessity and its formation is driven by the application of new technologies. In fact it is a self reinforcing mechanism of learning by doing that drives this process of appropriation and exploitation of knowledge.

Regional growth thus is mainly driven by investments in education and human capital, within a context of a modern administrative infrastructure and a responsive technological (or innovation) system. This process of growth does not lead to equal regions in the sense that all regions in the long run will become equally prosperous. Each region grows towards its own level of welfare, although there might be comparable regions that exhibit comparable growth.

Distance is an issue in itself because of spill over effects –from neighbours or networks - that enhance productive capacity of regions. These spillover effects are closely tight to codified knowledge making tacit knowledge the hidden treasure. Therefore interaction between people, networks and systems remains necessary to appropriate tacit knowledge.

In the course of time several kinds of capitals appeared in the theories and empirical models: physical, human, social and entrepreneurial capital. Each of the three different economic theories stresses the role of these capitals differently. While new growth theory adds knowledge to physical capital in its models of thought, it is the evolutionary approach that stresses the combination of many interacting factors within a careful designed technological system that is the key to regional upheaval and prosperity.

In a market economy human capital formation takes place as a response to market opportunities and its formation is often seen as one of the factors that drive "comparable" regions in the same direction. This is known in the literature as "club convergence". Knowledge and human capital make up the total of knowledge capital and has to be distinguished from physical capital. The accumulation of these two kind of capital are important in the process of catching up in Europe apart from the necessary conditions as macroeconomic stability and the functioning of the markets, specially capital markets and public infrastructure. Human capital is subjective knowledge that has been accumulated over the generations and when human capital formation is concentrated in agglomerations it is a source of polarisation and divergence.

Given the necessity to combine codified and tacit knowledge, attractive regions are the ones with certain levels (or stocks) of knowledge available together with user producer interaction proximity to markets and positive agglomeration effects. Trade between regions always is driven by unequal distribution of knowledge, (in)mobility of production factors, increasing returns and transportation costs. Entrepreneurship is seen as a response to opportunities created but not exploited yet. Entrepreneurs thus create their own path and seize the moment while the opposite of seizing the moment is being locked-in into a path dependent development.

Based on the economic theories the spatial distribution of welfare over the regions is often simplistic: core periphery allocations dominate the scene. However when more contextual factors are taken into account the allocations that can be explained becomes more complicated and realistic. Apart from pure agglomeration (cumulated knowledge and self reinforcing dynamics) other types of regions can be understood like: hub and spoke, satellite platform, state anchored configurations, specialised and diversified regions, institutional thin, restructuring old, fragmented metropolitan regions and many other types.

Conclusions

General conclusions based on the convergence discussion are hard to draw; however it appears that "technology" and "knowledge" very likely play important roles in explaining economic growth, together with regional institutional factors like labour market institutions, the regional absorption capacity and the quality of governance in general. The more recent studies on regional convergence show that there is no such thing as one model that fits all; it is rather convergence in diversity that is the case. Regions converge to the type to which they belong and from the evidence in the literature it appears that investments in education and human capital have great effect on absorptive capacities hence on potential regional growth.

The regional development processes are highly path-dependent due to their cumulative nature in the formation of human capital. Therefore the productivity discussion initiated by the neo-classical economists in the 1960's evolved into an evolutionary perspective in which not only the level of production was determined by technology that uses labour and capital, but also includes the use of knowledge, entrepreneurship and social capital and the impact of the context in which the production takes place. Especially Social capital is context dependent and can be seen as a further elaboration of knowledge and human capital. The social networks in which people operate make up social capital. In this perspective it is the combination of physical capital and human capital embedded in social capital that drives economic growth. Human capital contains tacit and explicit knowledge that people apply in their every-day's practice. Public knowledge itself is more encompassing because it consists of the information and routines that are available to anybody; private knowledge however is only accessible under certain conditions. Therefore human capital partly nurtured in the educational system merely is a condition sine qua non for economic growth and dynamics.

Regional economic growth depends indeed on a variety of factors. Labour and capital as inputs in the process of the production of goods and services is a caricature of what really happens in the region. Knowledge has been recognised as is a crucial driver of sustainable growth at the regional level. However knowledge is related to real activities in the region: production, R&D activities and the attitude towards risks are one side of the coin. The other is the incidence and richness of human, social and entrepreneurial capital. Proximity to other knowledge inherent in neighbouring economic activities, or networked activities produces spillovers that are beneficial for the economic performance of a region.

The empirical results indicate that apart from physical capital, human and entrepreneurial capital are important drivers of economic growth. Empirical work on the impact on especially entrepreneurial capital is hampered by lacking data on this kind of capital.

Knowledge settles in regions were there is much interaction between economic agents; the result is spatial disparities in the distribution of knowledge. Especially trade is seen as a major source of knowledge spillovers. The local impact of knowledge is multidimensional and cascaded: it might affect economic growth which impacts social and economic equity. Factor mobility on its turn depends on the quality of the local institutions and its endowments. These factors reinforce each other and lead to spatial disparities in the distribution of knowledge in agglomerations.

The exploitation of technological change and knowledge and innovation is to a large extent path dependent. The key factors determining this path dependency are the lack of entrepreneurial culture. Seizing the moment, essentially entrepreneurial behaviour is the opposite of path dependent development. Mindful deviation or path creation as the basic philosophy of the governance of technology in the region can break the chains of path dependency.

Annex 3 Foresight[10]

3.1 Design of the Foresight

The Foresight exercise comprises two parts: a survey of research, technology and innovation in European regions and a series of focus group workshops in the countries of the seven project partners. This section contains a short overview of the technical details of these Foresight activities.

3.1.1 Survey of research, technology and innovation in EU regions

The major aim of the survey is to analyze the differences between regions belonging to specific regional types regarding the role of research, technology development and innovation (RTI) for their further economic development.

The analysis of the survey results relates to the types of regions which were found by means of multivariate statistical analyses (Regional typology).

The survey of development and innovation in European regions was designed as an online-survey, where experts are asked by e-mail to fill a web-based questionnaire.

The survey covers a broad range of European regions. Several different sources were used to get response from regional experts, both from public and private RTDI experts, as well as policy experts in innovation policy. The first sets involved regional innovation policy experts named by the project partners and two EU innovation networks ("Innovating Regions", "B3 Regions"). An additional source was a database of RTI-experts comprising the addresses of participants of the 6th EU Framework Programme. Overall, we had about 3500 addresses.

The survey was send and available online from the end of June until July 2009. Experts were contacted and once reminded via e-mail. Overall, we received 408 responses, from which 329 were complete enough to be used. Within the sample of respondents the share of participants of the 6th EU Framework Programme was 50%. Respondents who were named by the project partners account for 36%. The remaining 14% come from the mentioned EU innovation networks. In the responding sample the presence of FP6 researchers is much lower than in the contact database. Besides policy makers, there is a good balance between response from basic science, applied research and business-oriented innovation in our sample. Table 1 shows the geographic distribution of respondents.

Overall, our sample consists of 329 persons from 26 countries of the EU, representing 123 regions at NUTS 2-level. By nation, the biggest group of respondents comes from Italy (65 respondents). Next is a group with around 30 respondents consisting of the Czech Republic, Spain and Germany. Between 15 and 25 respondents are from the Netherlands, Poland, France, the United Kingdom and Austria. All other countries are represented by 10 or less persons.

For the further analysis of the survey data, the regional types are central. Therefore it is interesting to know how many respondents belong to these seven types. The type with the most respondents is Skilled industrial technology regions with 75 persons having filled the questionnaire. Three types: Skilled industrial Eastern EU regions,

[10] Based on Foresight Report by AIT Austrian Institute of Technology GmbH

Metropolitan KIS regions and Knowledge absorbing services regions- have around 50 respondents each. The other three (Public knowledge centres, Traditional Southern EU and High-tech regions) have around 30 respondents each.

Table 1 Number of respondents and NUTS 2-regions by country

Country	Acronym	Respondents	Regions
Austria	AUT	15	6
Belgium	BEL	6	2
Bulgaria	BGR	6	4
Cyprus	CYP	1	1
Czech Republic	CZE	31	8
Germany	DEU	29	15
Denmark	DNK	3	1
Spain	ESP	30	10
Estonia	EST	3	1
Finland	FIN	4	2
France	FRA	17	6
United Kingdom	GBR	17	13
Greece	GRC	10	4
Hungary	HUN	7	3
Ireland	IRL	1	1
Italy	ITA	65	12
Lithuania	LTU	3	1
Luxemburg	LUX	2	1
Latvia	LVA	2	1
Netherlands	NLD	25	8
Poland	POL	25	10
Portugal	PRT	2	2
Romania	ROU	5	3
Slovakia	SVK	7	3
Slovenia	SVN	4	1
Sweden	SWE	9	4
Total		329	123

Source: ETEPS-survey of research, technology and innovation in European regions, 2009

3.2.2 Focus group workshops

The aim of the workshops is twofold. The main focus is on the elaboration of different possible story-lines (or scenario-sketches) for future regional development (until 2020), combining the consolidated survey results with RTI-policy measures (also based on the survey). This helps to identify pressing issues for the particular types of regions and as well as communalities within types of regions.

The second aim is to get deeper knowledge about the results of the online-survey. This is done by developing a consensual view on the survey results by the workshop participants. The intention is to better understand the results and regional particularities.

Storylines are understood as formulated short scenario-sketches of one paragraph combining a limited number of drivers or factors influencing the regional development over the next 11 years to a chain of arguments. It is a creative process of identifying the most important linkages between drivers or factors of the different categories (challenges, barriers, policies) which have been identified in the survey. Based on the story-lines, the project team elaborates the scenario-sketches for each of the selected types of regions. The robustness of the scenarios has also been discussed with external experts who were invited to a workshop on task 4 in Brussels (25/9/2009).

The focus group meetings were organized by the seven project partners in their respective countries. Each partner was in charge of one specific type of region, derived from the typology report. Finally, workshops for six of the seven types were held in the following regions:

Table 2 Focus group regions

Country	Type of region	Region
Austria	Skilled technology regions	Upper Austria
Czech Republic	Skilled industrial Eastern EU regions	Whole country except Prague
Germany	High-tech regions	Karlsruhe, Darmstadt
Italy	Skilled technology regions	Northern Italy
Netherlands	Metropolitan knowledge-intensive services regions Knowledge absorbing services regions	Noord- & Zuid-Holland Gelderland, Overijssel
Poland	Skilled industrial Eastern EU regions	Malopolskie, Slaskie
Spain	Traditional Southern EU regions	Valencia, Andalucia

Skilled technology regions were investigated with workshops in Austria and Italy; Skilled industrial Eastern EU regions with workshops in the Czech Republic and Poland. Public knowledge centres were not investigated in this second phase of the Foresight exercise. Most focus group workshops focused on one or two regions of the same type. The Czech workshop covered all regions of the country except for Prague, which is the only Czech region that does not belong to Skilled industrial Eastern EU regions. The Italian workshop had participants from several Skilled technology regions in Northern Italy, mostly from Lombardia, Piemonte and Emilia Romagna.

3.3 RTI and regional development in the EU: challenges, barriers and policies

In this section three aspects concerning the role of RTI for the economic development of European regions are discussed: challenges for economic development, barriers hampering RTI and policy measures aiming at strengthening the impact of RTI on regional growth. This section is based on data from our RTI-survey and the discussion of the results of the survey in the focus group workshops. The workshops turned out to be important with regard to interpreting and qualifying several results of the survey.

3.3.1 Challenges for economic development in European regions

Survey question: "What are the major challenges for your region's society and its economic development (growth and employment)? How important are these challenges?"

The respondents were asked to assess a list of 18 challenges and could choose one of the following five predefined answers for each of them: 'very important', 'important', 'not very important', 'not important at all' or 'don't know'. The results for the whole sample of 329 respondents are presented in table 5.3 of the main text.

Looking only at the rate of 'very important'-indications, 'education and training' leads the ranking before 'employment' and 'energy security and renewable energy sources'. It is remarkable that insufficient quality of education and training institutions is seen as one of the most serious challenges for the development of regions and its economy, clearly ahead of other challenges like 'climate change' or 'shrinking population', which are currently much more intensively debated. A lack of qualified knowledge and the ability to solve complex problems due to inadequate education institutions is obviously seen as more critical than most of the particular social and economic problems per se.

Most environmental problems are seen as critical challenges. 'Sustainable development', 'environmental protection' and 'renewable energy' all belong to the most frequently mentioned important or very important challenges. For two environmental issues this does not apply: 1) Water shortage is a challenge only in a specific part of Europe; 2) The consequences of climate change are obviously still too blurred to accept it unequivocally as a serious regional challenge.

With regard to structural policy of the EU it is remarkable that regional development is one of the challenges that were quite often assessed as important or even very important.

The least important challenges are 'migration', 'shrinking population/labour force', 'safety', 'social polarization' and 'climate change'. Overall, the respondents have little doubt about their view of the listed challenges. Only very few could not give an assessment.

With regard to the regional types there are some particular differences in the assessment of these challenges. A comparison of the results by type is presented in table 3 (at the end of this section)

Respondents from Metropolitan KIS regions reported ‘ecurity and renewable energy sources' and 'employment' most often as very important challenges, which is very 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'. Challenges that are clearly less often mentioned are 'regional development' and 'migration'.

Experts from Knowledge absorbing regions indicated ‘sustainable development', 'regional development' and 'employment' most often as very important challenges, which is quite distinct from the assessment of the whole sample. Challenges that are clearly more often mentioned by respondents from these regions are 'sustainable development', 'medicine and health', 'regional development', 'social polarization' and 'security'. Challenges that are clearly less often mentioned are 'information and media' and 'safety'.

Respondents from Public knowledge centres indicate 'education and training', 'medicine and health' and 'sustainable development' most often as very important challenges. This is also quite distinct from the whole sample. Challenges that are clearly more often mentioned respondents from these regions are 'social polarization', 'safety' and 'security'. But there are more challenges that are clearly less often mentioned: 'globalization', 'climate change', 'environmental protection', 'energy security', 'employment' and 'regional development'.

Respondents for Skilled industrial Eastern EU regions indicate 'employment', 'regional development' and 'medicine and health' as well as 'education and training' most often as very important challenges, which is slightly different to the whole sample. Challenges that are clearly more often mentioned are 'shrinking population and labour force', 'medicine and health', 'economic welfare', 'employment', 'regional development' and 'social polarization'. Challenges mentioned less often are: 'globalization', 'climate change', 'sustainable development', 'information and media', 'safety' and 'security'.

Respondents in High-tech regions indicate 'globalization', 'sustainable development' and 'education and training' most often as very important challenges. Challenges that are more often mentioned in these regions are: 'globalization', 'climate change', 'sustainable development', 'shrinking population and labour force' and 'regional development'. Challenges less often mentioned are: 'water resources', 'migration', 'employment', 'social polarization', 'safety' and 'security'.

Respondents in Skilled technology regions on average indicate 'energy security and renewable energy sources', 'employment' and 'education and training' most often as very important challenges. Challenges more often mentioned by respondents for this type of regions are: 'globalization', 'energy security', 'ageing', 'migration', and 'safety'. Less often mentioned challenges are: 'water resources', 'medicine and health' and 'social polarization'.

Traditional Southern EU regions indicate 'water resources', 'employment' and 'education and training' most often as very important challenges, which differs in one respect to the whole sample. In particular the challenge of 'water resources', is a very specific challenge for the South of Europe. Other challenges mentioned more often are: 'globalization', 'sustainable development', 'employment', 'regional development' and 'safety'. Challenges that are clearly less often mentioned by type 7 respondents are 'ageing' and 'shrinking population and labour force'.

The discussion on the challenges in the focus groups shows that the results for the whole type widely correspond with the consensual view of the focus groups. Discrepancies can be described by particularities of the specific region.

Globalization is seen as a challenge mainly by respondents from High-tech regions which may be related to the competition on high-tech products in an open market. For other types it is not very important compared to other challenges.

Climate change seems to be not on the radar yet for most regions. The same is true for migration.

The high importance of energy security and renewable resources is confirmed by the workshops for all types that indicate high importance of these issues in the survey. It is seen more often as a threat than an opportunity for the region. This might also be closely related to energy intensities. In the Czech focus group, however, the opportunities regarding nuclear energy are highlighted.

Economic welfare is seen as a challenge in Skilled industrial Eastern EU regions. This is understandable as the new member states are still struggling with catching up and closing the gap in terms of economic welfare.

Employment is seen as a quite important challenge in most types. However, from the local focus group workshops it appeared that this does not necessarily refer to the problem of unemployment. In several cases it is seen as a problem in terms of lack of qualified personnel.

Education and training is seen as one of the top 3 challenges in all types of regions. It forms the challenge that is relevant for all of Europe’s regions.

3.3.2 Barriers hampering research, technology and innovation

Survey question: "Do the following barriers seriously hamper research, technology and innovation in your region?"

The respondents could indicate whether they agree that certain types of barriers are constraining RTI in their region or not. Overall, 13 types of barriers were listed (see table 5.4 in the main text).

The most frequently indicated barrier is the lack of (risk) capital. It is the only barrier that receives a rate of agreement close to two thirds of respondents. A majority agreeing can be found by four further barriers: 'limited production, transfer and use of knowledge', 'limited cross-sectoral collaboration', 'lack of entrepreneurship' and, a very recent problem, 'longer-term negative effects of the financial crisis on the funding of R&D'. Some potential barriers are hardly seen as being serious, at least as the own region is concerned. This applies to barriers where the rate of disagreement surpasses the rate of agreement: 'lack of qualified human resources', 'limited use of ICT' and 'unattractive living and working conditions'.

Regional types differ with respect to specific types of barriers:
The barriers most frequently mentioned by Metropolitan KIS respondents are: 'lack of entrepreneurship', 'negative effects of the financial crisis' and 'lack of capital' (see table 4). These respondents indicate almost all barriers less often than the whole sample, except for 'lack of entrepreneurship'.
The top three barriers in Knowledge absorbing regions are 'limited production, transfer and use of knowledge', 'limited cross-sectoral collaboration' and 'lack of capital'. The barriers 'lack of human resources', 'limited production, transfer and use of knowledge', limited knowledge creation' and 'limited use of ICT' are more often mentioned than the whole sample, the barriers 'lack of capital', 'insufficient government services' and 'unattractive living/working conditions' clearly less often.

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 government services', with the third highest rate of agreement. Respondents indicate the barriers 'lack of R&D infrastructure', 'limited cross-sectoral collaboration', 'limited production, transfer and use of knowledge', 'insufficient government services' and 'unattractive living/working conditions' more often than the whole sample, the barriers 'lack of human resources', 'negative effects of the financial crisis', 'lack of entrepreneurship' and 'limited use of ICT' less often.

The barriers most frequently mentioned for Skilled industrial Eastern EU regions are 'lack of R&D infrastructure', 'limited production, transfer and use of knowledge' and 'lack of capital'. Respondents from these regions indicate almost all barriers more often than the whole sample. The exceptions are 'negative effects of the financial crisis' and 'lack of entrepreneurship'.

Respondents of High-tech regions mention 'lack of capital', 'negative effects of the financial crisis' and 'lack of entrepreneurship' most frequently as serious barriers. These respondents indicate most barriers less often than the whole sample, except for 'lack of capital' and 'negative effects of the financial crisis'.

The barriers most frequently mentioned in Skilled technology regions are almost the same as those of High-tech regions: 'lack of capital', 'negative effects of the financial crisis', 'limited cross-sectoral collaboration' as well as 'lack of entrepreneurship'. Less frequently mentioned are the barriers 'limited knowledge creation' and 'limited use of ICT'.

The respondents of Traditional Southern EU regions stress barriers most that are already known from the other types: 'lack of capital', 'limited production, transfer and use of knowledge' and 'limited cross-sectoral collaboration'. Traditional Southern respondents 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; the barriers 'lack of human resources' and 'unattractive living/working conditions' less often.

Overall, we find that the lack of R&D-infrastructure is seen as most important in Skilled industrial Eastern EU regions. This is seen as a very peculiar issue in the new member states. It is much less important for all other types including the Traditional Southern EU regions.

The lack of available (risk) capital is seen as the most important barrier in 4 types of regions. And it is among the top 3 most important barriers in all types of regions.

Limited cross-sectoral collaboration is seen as very important in most types of regions. Relatively low importance is given to this issue in Metropolitan KIS regions and High-tech regions.

3.3.3 Policy measures to strengthen the impact of RTI on growth in European regions

Survey question: "Which policy measures do you think to be particularly necessary to strengthen the impact on growth from research, technology and innovation in your region?"

The respondents could assess a given list of 16 types of policy measures as 'particularly necessary', 'less important' or 'not important'. They could also answer not to know enough about a specific measure to be able to assess it (see table 5.5 in the main text).

In general respondents see a lot of policy actions to be necessary. The strongest agreement for necessary policy measures are: 'spend more on co-funding of applied R&D and innovation' and 'run a more research- and innovation-friendly economic policy'. In addition to these top ranking measures nine further types of measures receive rates of agreement of more than 50%. Almost no type of measure is assessed to be unimportant by a more than negligible share of respondents. Only in two cases - 'improve soft location factors' and 'establish or extend public research organizations' - the share of respondents indicating 'not important' is more than 10%.

The most frequently mentioned particularly necessary policy measures by Metropolitan KIS respondents are: 'more co-funding of applied R&D', 'better education and training' and 'a more research/innovation-friendly economic policy' (see table 5 at end of this section). Almost all policy measures are less often indicated by these respondents than in the whole sample, except for 'promotion of ICT' and 'improvement of soft location factors'.

The top priority policy measures in Knowledge absorbing regions are 'more co-funding of applied R&D', 'measures against the financial crisis' and 'a more research/innovation-friendly economic policy'. 'More co-funding of applied R&D' and 'measures against the financial crisis' are clearly more often indicated, 'more networking within and outside the region', 'more foreign investment', 'support of mobility of qualified people' and 'a more research/innovation-friendly legal environment' less often.

In Public knowledge centres 'more co-funding of applied R&D', 'a more research/innovation-friendly legal environment' and 'a more research/innovation-friendly economic policy' are mentioned most frequently as particularly necessary policy measures. Those that are more frequently indicated are: 'more co-funding of research', 'more co-funding of applied R&D', 'better education and training', 'additional venture capital', 'more foreign investment', 'a more research/innovation-friendly legal environment' and 'a more research/innovation-friendly economic policy'.

Respondents in Skilled industrial Eastern EU 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: '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'.

Respondents of High-tech regions are focusing especially on 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 responding experts from High-tech regions ('new/extended public research organizations', 'additional venture capital' and 'measures against the financial crisis'), some less often ('better education and training', 'more foreign investment', 'a more research/innovation-friendly legal environment', 'a more research/innovation-friendly economic policy', 'a regional RTI-strategy process' and 'better coordination of regional, national and European RTI-policies').

The most frequently mentioned particularly necessary policy measures by Skilled technology regions are 'more co-funding of applied R&D', 'a more research/innovation-friendly economic policy' and 'better education and training'. Almost all policy measures are more often indicated than in the whole sample, except for 'new/better technology intermediaries', 'promotion of ICT' and 'improvement of soft location factors'.

The most important policy measures for respondents of Traditional Southern EU regions are quite distinct from those in other types. 'Better coordination of regional, national and European RTI-policies', 'a more research/innovation-friendly economic policy' and '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 respondents of this type of 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', 'better education and training', 'more foreign investment' and 'improvement of soft location factors').

We see that there are some policy measures that rank high in almost all types of regions. This applies especially to 'more co-funding of applied R&D' and 'a more research/innovation-friendly economic policy'.
Improving public education and training is top 4 of 16 listed policy measures for five types of regions.
The topic of policy measures to make the legal framework more research- and innovation-friendly is ranked the top priority in Public knowledge centres and Skilled industrial Eastern EU regions.
Policy measures related to more research- and innovation-friendly economic policy is the second or third most important issue in all types.
In types of regions where networking-related measures are seen as important (Skilled industrial Eastern EU regions, Skilled technology regions and Traditional Southern EU regions) there is also seen room for policy measures related to organizing or supporting RTI-strategy processes. Respondents of these regional types seem to be more sensitive to cooperation in RTI-activities, and they also indicate this as an important barrier.

Interestingly, the coordination of RTI-policy between regional, national and EU levels is seen as the most important issue in Traditional Southern EU regions. This might be related to the relatively high share of resources coming to these regions via the EU.

Table 3 Share of 'Very important' regional CHALLENGES for society and economic development

	All regions	Metropolitan knowledge-intensive services regions	Knowledge absorbing regions	Public knowledge centres	Skilled industrial Eastern Europe	High-tech regions	Skilled industrial technology regions	Traditional Southern Europe
Education and training	47.1	54.5	42.2	45.9	42.9	50.0	45.3	51.5
Employment	46.5	45.5	46.7	29.7	58.9	32.1	46.7	57.6
Energy security and renewable energy sources	43.2	47.3	40.0	32.4	41.1	39.3	49.3	45.5
Sustainable development	39.8	38.2	51.1	35.1	25.0	50.0	41.3	45.5
Globalization	38.9	36.4	33.3	29.7	28.6	64.3	44.0	45.5
Regional development	38.6	21.8	51.1	27.0	44.6	46.4	37.3	48.5
Environmental protection	37.7	43.6	35.6	32.4	37.5	32.1	41.3	33.3
Medicine and health, sustainable healthcare systems	35.3	32.7	42.2	37.8	42.9	39.3	25.3	33.3
Ageing	31.6	34.5	28.9	29.7	30.4	28.6	41.3	15.2
Economic welfare	28.9	27.3	24.4	27.0	41.1	32.1	25.3	24.2
Water resources	26.1	30.9	22.2	21.6	21.4	10.7	20.0	63.6
Climate change	22.8	41.8	26.7	10.8	8.9	32.1	18.7	24.2
Information and media	20.4	27.3	13.3	24.3	10.7	25.0	22.7	21.2
Shrinking population, shrinking labour force	17.0	16.4	13.3	16.2	28.6	21.4	14.7	6.1
Safety (safety at work, industrial hazards)	16.7	14.5	8.9	24.3	3.6	0.0	33.3	21.2
Social polarization	15.8	18.2	22.2	21.6	21.4	3.6	9.3	12.1
Migration	15.5	9.1	13.3	13.5	17.9	3.6	24.0	18.2
Security (personal security, antiterrorist protection)	13.7	10.9	20.0	18.9	8.9	7.1	16.0	12.1

Table 4 Share of 'Very important' relevance of certain BARRIERS hampering RTI in the region

	All regions	Metropolitan knowledge-intensive services regions	Knowledge absorbing regions	Public knowledge centres	Skilled industrial Eastern Europe	High-tech regions	Skilled industrial technology regions	Traditional Southern Europe
Lack of available (risk) capital	64.4	40.0	55.6	67.6	71.4	64.3	77.3	72.7
Limited production, transfer and use of knowledge	55.3	36.4	60.0	62.2	73.2	17.9	58.7	66.7
Limited cross-sectoral collaboration	53.8	38.2	57.8	59.5	60.7	32.1	61.3	57.6
Long-term negative effects of financial crisis on funding of R&D	50.8	41.8	46.7	43.2	50.0	57.1	61.3	51.5
Lack of entrepreneurship	50.8	50.9	53.3	45.9	41.1	46.4	61.3	48.5
Insufficient quality of government services	48.3	29.1	42.2	62.2	64.3	25.0	54.7	51.5
Lack of R&D infrastructure	44.7	23.6	42.2	54.1	75.0	17.9	45.3	42.4
Limited foreign investments	44.7	27.3	40.0	40.5	57.1	17.9	58.7	54.5
Limited inter-regional collaboration	42.2	27.3	44.4	43.2	51.8	25.0	46.7	51.5
Limited knowledge creation capacities	41.3	25.5	48.9	40.5	62.5	25.0	40.0	39.4
Lack of qualified human resources	38.6	29.1	44.4	27.0	53.6	32.1	44.0	27.3
Limited use of ICT	32.5	27.3	37.8	18.9	37.5	14.3	33.3	54.5
Unattractive living and working conditions	26.1	21.8	20.0	35.1	39.3	7.1	29.3	18.2

Table 5 Share of 'Very important' agreement of POLICY MEASURES to strengthen the impact of RTI on regional growth

	All regions	Metropolitan knowledge-intensive services regions	Knowledge absorbing regions	Public knowledge centres	Skilled industrial Eastern Europe	High-tech regions	Skilled industrial technology regions	Traditional Southern Europe
Spend more on co-funding applied R&D/innovation projects	69.9	52.7	75.6	70.3	71.4	67.9	84.0	57.6
Run a more research- and innovation-friendly economic policy	64.4	49.1	60.0	64.9	71.4	57.1	76.0	63.6
Improve the public education and training system	60.5	52.7	57.8	59.5	57.1	53.6	76.0	54.5
Make the legal environment more research/innovation-friendly	60.2	41.8	48.9	70.3	73.2	53.6	69.3	57.6
Spend more on co-funding research projects	55.3	34.5	55.6	56.8	58.9	53.6	72.0	45.5
Offer additional venture capital	53.2	38.2	51.1	51.4	51.8	64.3	61.3	57.6
Fight the financial crisis to avoid companies spending less on R&D	53.2	40.0	64.4	35.1	44.6	67.9	66.7	51.5
Organize or support a regional RTI strategy process	52.0	30.9	51.1	45.9	60.7	42.9	62.7	63.6
Support the mobility of qualified personnel	51.4	43.6	44.4	37.8	53.6	53.6	65.3	51.5
Support networking between agents within/outside the region	50.8	40.0	44.4	32.4	53.6	50.0	65.3	60.6
Better coordinate regional RTI with national and European RTI-policies	50.2	32.7	46.7	43.2	48.2	39.3	66.7	66.7
Attract more foreign investment	47.7	36.4	40.0	48.6	53.6	39.3	61.3	42.4
Promote Information and communication technologies	43.2	45.5	40.0	37.8	44.6	39.3	42.7	51.5
Establish new/support existing intermediaries like technology centres	38.9	29.1	37.8	24.3	53.6	39.3	38.7	48.5
Establish new/extend existing public research organizations	36.8	32.7	37.8	21.6	39.3	50.0	42.7	30.3
Improve the soft location factors	28.3	30.9	28.9	27.0	26.8	32.1	29.3	21.2

3.4 Important economic sectors for regional development in Europe

Survey 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?"

Up to five sectors could be mentioned. Therefore the number of indications surpasses the number of respondents. The sectors could be selected from a list of NACE-classes, most of them at NACE 2 level, some at NACE 3 level, some NACE-classes have also been aggregated (see table 6). Overall, 38 sectors are indicated by the respondents. The indications of the whole sample as well those of the respondents of each type of region are presented in table 6:

Table 6 Importance of economic sectors for regional development, number of respondents by type of region

Sector	All	Type of region						
		Metro. KIS	Knowl. absorb.	Pub. K. Centres	S.I. East EU	High-tech	S.Technology	Trad. South.
Agriculture, forestry, fishing	70	4	10	12	13	2	15	15
Mining and quarrying	5	0	0	0	4	0	1	0
Food products, beverages and tobacco	59	4	8	5	10	0	21	11
Textiles, textile products, clothes and leather products	17	0	2	1	4	0	7	3
Wood, wood products and furniture	21	0	0	1	14	0	4	2
Pulp, paper and paper products	4	3	1	0	0	0	0	0
Publishing, printing and reproduction of recorded media	9	2	1	1	0	2	3	0
Coke, refined petroleum products and nuclear fuel	9	0	2	2	2	0	1	2
Chemicals, chemical products and man-made fibres (excl. pharmaceuticals)	45	11	10	4	3	3	11	3
Pharmaceuticals	64	14	14	6	8	5	13	4
Rubber and plastic products	6	0	1	0	3	0	2	0
Non-metallic mineral products (glass, ceramic, stone)	8	0	1	0	1	0	3	3
Basic metals	13	2	1	0	5	1	4	0
Fabricated metal products	35	5	4	2	10	4	6	4
Machine-tools, special-purpose machinery	58	6	5	3	15	12	16	1
Office machinery and computers	13	0	3	2	2	1	4	1
Electrical machinery and apparatus	45	5	5	5	13	6	10	1
Radio, television and communication equipment	27	7	1	2	5	2	5	5
Medical, precision and optical instruments, watches and clocks	45	10	6	2	5	9	12	1
Motor vehicles	76	2	7	7	11	17	29	3
Ships, railway	24	3	10	1	3	0	5	2
Aircraft and spacecraft	33	1	7	2	1	3	13	6
Jewellery, musical instruments, sports goods, games and toys	1	0	0	0	0	0	1	0
Recycling	38	6	2	3	6	1	13	7
Electricity, gas and water supply	55	8	9	8	6	1	14	9
Construction	53	5	9	8	10	4	7	10

Wholesale and retail trade, repair	17	6	2	2	1	1	2	3
Hotels and restaurants	74	11	9	10	18	2	11	13
Transport, storage and communication services	80	17	10	9	14	6	15	9
Financial intermediation	18	6	1	4	3	2	2	0
Real estate and renting services	10	4	1	2	1	1	1	0
Computer and data services	57	10	9	8	17	4	7	2
Software	45	6	9	6	9	5	9	1
Research and development (contract research)	118	23	16	17	18	12	26	6
Business services (consultancy, advertising, cleaning etc.)	55	16	6	8	6	4	8	7
Public administration	38	7	7	8	3	2	6	5
Education	89	19	13	17	15	9	13	3
Health and social work	73	23	9	7	7	6	15	6

Source: ETEPS-survey of research, technology and innovation in European regions, 2009

Overall, the respondents expect the following sectors to be the most important ones in the nearer future: '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'.

Research and development clearly leads the ranking, but due to the fact that this sector covers all fields of R&D, it does not tell us anything about the targets of the actual R&D-activities. It only shows how important the respondents think that R&D is for the economic development of regions overall. More interesting are the other sectors which are often quite traditional sectors, which are still expected to be of high importance for future growth and employment: 'transport, storage and communication services', 'motor vehicles', 'hotels and restaurants', 'agriculture, forestry and fishing', 'food products, beverages and tobacco', 'machine-tools and special-purpose machinery'. These are six out of the top ten sectors!

Education ranks very high in the assessment of the respondents. This means that many respondents are convinced that teaching knowledge and building capacities which can later be used for R&D and innovation activities in many fields of technology and the economy are of critical importance. This shows that they do not think that relying on R&D and innovation capacities already available in the industries will be sufficient in the future.

Several sectors are rarely mentioned. Most of them are basic materials industries like 'mining and quarrying', 'pulp, paper and paper products', 'coke, refined petroleum products and nuclear fuel', 'rubber and plastic products' and 'non-metallic mineral products'. A few others are very small and highly specialized sectors like 'publishing, printing and reproduction of recorded media' and 'jewellery, musical instruments, sports goods, games and toys'.

Of course, the particular importance of an economic sector is often type-specific. There are several significant differences between types of regions in this respect:

The most important sectors indicated by respondents in Metropolitan KIS regions are very similar to the whole sample. 'General research' dominates the list of top 10 sectors. 'Business services', 'chemicals', 'medical, precision and optical instruments, watches, clocks' and 'computer services' are specifically important in Metropolitan KIS regions. Services are predominant (seven sectors of the top 10). Only three manufacturing industries are under the top 10 sectors of this type: 'pharmaceuticals', 'chemicals' and 'medical, precision and optical instruments, watches, clocks'.

The most important sectors indicated by Knowledge absorbing regions differ in some respects from the whole sample. While 'general research' dominates the list of top 10 sectors in both cases, 'chemicals', 'ships and railway', 'electricity/gas/water supply' and 'construction' are specifically important in Knowledge absorbing regions. 'Pharmaceuticals' rank especially high. Non-service industries are frequent under the top 10 sectors of these regions: 'pharmaceuticals', 'chemicals', 'ships and railway' as well as 'agriculture', 'construction' and 'electricity/gas/water supply'.

Some differences from the whole sample can also be found in the case of Public knowledge centres. While 'general research' and 'education' dominate the list of top 10 sectors in both cases, 'electricity/gas/water supply', 'construction', 'computer services', 'business services' and 'public administration' are specifically important in Public knowledge centres. There is not a single manufacturing industry under the top 10 sectors for this type of regions!

Quite different from the whole sample are Skilled industrial Eastern EU regions. 'Tourism' dominates, 'general research' ranks only second. 'Computer services', 'wood (products)' and 'electrical machinery' are specifically important in these regions. Manufacturing is quite important in Skilled industrial Eastern EU regions with four industries ('machine-tools', 'wood (products)', 'electrical machinery', 'motor vehicles') among the top 10 sectors.

High-tech type of regions are very different compared with the other types. 'Motor vehicles' and 'machine-tools' dominate, 'general research' ranks only third. 'Medical, precision and optical instruments, watches, clocks', 'electrical machinery' and 'software' are specifically important in High-tech regions. Manufacturing is very important in High-tech regions with five industries ('motor vehicles', 'machine-tools', 'medical, precision and optical instruments, watches, clocks', 'electrical machinery' and 'pharmaceuticals') within the top 10 sectors.

Skilled technology regions have also a very distinctive list of favoured sectors. 'Motor vehicles' is most important, 'general research' ranks second. 'Electricity/gas/water supply' and 'aircraft and spacecraft' are specifically important in this group of regions. Manufacturing is very important too with five industries ('motor vehicles', 'food', 'machine-tools', 'pharmaceuticals' and 'aircraft and spacecraft') among the top 10 sectors.

The list of most important sectors in Traditional Southern EU regions has a very specific profile. 'Agriculture', 'tourism' and 'food' are reported as the three most important sectors for the future. 'General Research' appears only at the tenth place, which is very different from all other types. 'Electricity/gas/water supply', 'recycling', 'business services' and 'aircraft and spacecraft' are specifically important in Traditional Southern EU regions. There are only two important manufacturing industries in this type of regions: 'food' - a traditional industry - and 'aircraft and spacecraft' - a modern industry.

The assessment of sectors presented above has a serious drawback: The sectors that could be indicated were based on the present NACE-classification of industrial activities. As any industrial classification NACE is based on the economic structures of the past. With these classes given it is very difficult to capture the ongoing developments of new techno-economic fields. This became apparent in the discussions in the focus group workshops as well as in the analysis of the survey results concerning the most important technologies for future development.

The respondents were asked to name the technologies they expect to be the most important ones for developing the sectors they had indicated before. They were free how to describe them. There was no list of predefined technologies. The list of the technologies the respondents expected to be the most crucial ones for future development is very different from the selected NACE-classification sectors.

Question: "Which technologies do you expect to be the most crucial ones for the development of the sectors mentioned above?"

Up to five technologies could be mentioned. Due to the fact that we did not offer a list of technologies, the answers had to be standardized afterwards by ourselves. This task was not easy, because the descriptions ranged from very general/abstract to extremely concrete/detailed. After all, we have come up with rather general technology categories. Looking at them we find that the most frequently mentioned technologies are usefull in many economic sectors (see table 7; see also the further aggregation in table 5.2 of main text).

Table 7 The most frequently mentioned technologies

Technology categories	Number of indications
Information and communication technologies	123
Alternative energy technologies	81
Nanotechnology and nanomaterials	56
Biotechnology	52
New materials	45
Health technologies	32
Computing, mathematics	29
Environmental technologies	23
Process technologies	22
Internet technologies	20
Alternative automotive technologies	18
Control technologies	13
Electronics	13
Logistics	13
Automation	12
Software	12
Computer technologies	9
New education technologies	9
Robotics	8
Systems analysis and modelling	8
Agricultural technologies	7
Food technologies	7
Chemistry	6
Pharmaceutical technologies	6
Biochemistry	5
Life sciences	5
Mechatronics	5
Water technologies	5
Machinery	5
Construction technologies	4
Aircraft/aerospace technologies	3
Quality certification	3
Basic natural sciences	3
Artificial Intelligence	2
Fluid dynamics	2
Laser technologies	2

Source: ETEPS-survey of research, technology and innovation in European regions, 2009

Most often the respondents mentioned ICT technologies, followed with some distance by technologies which belong to the field of alternative (renewable) energy. Third come nanotechnologies and nanomaterials and fourth biotechnology. The list of technologies is quite long, because some answers could not be unambiguously assigned to bigger categories. So some categories are more specific than others which leads to several categories with a very small number of indications (e.g. artificial intelligence, fluid

dynamics). It is important to consider that this list is not based on a strict hierarchical classification of technologies.
The list of technologies presented in table 12 underlines the shortcomings of the distinction of economic activities and related R&D based on traditional industrial classifications like NACE. Many of the technologies listed clearly cut across several industries. This applies also to the most often mentioned technologies. ICT is the top ranking field of technology, and it is one of the critical technologies in almost any industry. The same applies to software. But it does not stop with the digital world. There are several high-ranking technology fields that are also important for several industries today: biotechnology (with the biggest potential in food, health and many industrial processes), nanotechnology and new materials (potentially useful in almost any manufacturing industry) or automation and robotics.

Linking the sector and the technology perspectives leads to the conclusion that 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 where they can transform them into completely new industries or into new hybrid industries, linking formerly distinct industries. A good example for the latter process is mechatronics combining machinery and electronics.

The generic nature of many important future technologies and the blurring of boundaries between industries became also apparent in the focus group workshops when discussing the sectors that were expected to be the most important ones in the development of the respective regions. In the following, we present an overview of the cases from the focus group workshops which exemplify best the importance of cross-sector technologies and the blurring of boundaries between industries:

- In the case of "Knowledge absorbing services regions" in the Netherlands one story-line links the food industry, sustainable agriculture, biotechnology and the health sector. A strong link between the food industry and biotechnology also appears in the case of Traditional Southern EU regions in Spain.

- Another traditional sector where links to new fields of technology are found to be important is textiles. In the case of Knowledge absorbing regions in the Netherlands the story-lines link the textile and chemical industries with new fibres (new materials). In the workshop of Traditional Southern EU regions in Spain textiles and clothes are linked more broadly with new materials, nanotechnology, software and automation.

- That there are many links between new technologies and both traditional and more high-tech industries show the story-lines of Skilled industrial technology regions in Italy. On the workshop story-lines have been developed which link new materials and nanotechnology with pharmaceuticals, textiles and the aircraft/spacecraft industry.

- In the workshop on Skilled industrial Eastern EU regions in the Czech Republic the industry 'medical, precision and optical instruments' is discussed together with material engineering.

- Interesting links in an environmental and health context are found in the case of Skilled industrial Eastern EU regions in Poland. The respective story-line combines water recycling, medicine and health, biochemistry and biotechnology.

- The generic nature of information and communication technologies is central in the workshop of High-tech regions in Germany. There ICT and software are linked with office machinery, machine-tools and the automotive sector.

- Similar story-lines have been developed around mechatronics (a new sector for itself). In the case of the Austrian Skilled industrial technology region the combination is between mechatronics and software, in the Italian case it is between mechatronics, robotics and machinery.

In addition to information about the most important economic sectors of the future we were also interested in the types of knowledge activities needed to develop these regional sectors. Three broad types of knowledge activities were distinguished: 1) scientific knowledge produced by basic science and research, 2) technical knowledge produced in applied technology development and innovation, and 3) the fundamental knowledge, taught at higher education institutions, which is required later in different fields of RTI.

Table 8 Importance of types of knowledge activities for the development of selected promising sectors, mean value of importance according to ranking on a scale from ('unimportant') 1 to 5 ('very important')

	Basic science	Applied development	Higher education
Agriculture, forestry, fishing	3.70	3.86	3.73
Mining and quarrying	3.25	3.50	3.50
Food products, beverages and tobacco	3.30	4.09	3.70
Textiles, textile products, clothes and leather products	3.35	4.06	3.71
Wood, wood products and furniture	3.30	3.90	3.85
Pulp, paper and paper products	3.00	4.00	3.00
Publishing, printing and reproduction of recorded media	2.78	3.89	3.89
Coke, refined petroleum products and nuclear fuel	4.33	4.67	4.56
Chemicals, chemical products and man-made fibres (excl. pharmaceuticals)	3.82	4.26	4.11
Pharmaceuticals	4.45	4.31	4.38
Rubber and plastic products	4.17	4.33	4.50
Non-metallic mineral products (glas, ceramic, stone)	3.71	4.57	3.86
Basic metals	3.08	3.92	3.25
Fabricated metal products	3.18	4.06	3.64
Machine-tools, special-purpose machinery	3.60	4.43	4.15
Office machinery and computers	3.33	3.92	3.75
Electrical machinery and apparatus	3.45	4.23	4.13
Radio, television and communication equipment	4.00	4.23	4.24
Medical, precision and optical instruments, watches and clocks	4.16	4.37	4.08
Motor vehicles	3.56	4.31	3.77
Ships, railway	3.33	4.33	3.78
Aircraft and spacecraft	4.29	4.45	4.06
Jewellery, musical instruments, sports goods, games and toys	3.00	3.00	3.00
Recycling	4.06	4.42	4.12
Electricity, gas and water supply	3.86	4.32	3.79
Construction	2.89	3.72	3.28
Wholesale and retail trade, repair	2.13	3.40	3.33
Hotels and restaurants	2.13	2.97	3.49
Transport, storage and communication services	3.17	3.93	3.49
Financial intermediation	2.59	3.39	3.88
Real estate and renting services	1.78	2.11	2.67
Computer and data services	3.82	4.49	4.16
Software	3.58	4.49	4.26
Research and development (contract research)	4.33	4.44	4.56
Business services (consultancy, advertising, cleaning etc)	2.43	3.53	3.83
Public administration	2.55	3.21	3.68
Education	3.77	3.95	4.36
Health and social work	3.66	3.97	4.08

Source: ETEPS-survey of research, technology and innovation in European regions, 2009

The assessment of the types of knowledge refers to the sectors indicated by the respondents as the most important economic sectors for the future development of their regions. The respondents could rank each type of knowledge on a scale ranging from 1 ('unimportant') to 5 ('very important') for all the economic sectors they had mentioned in the question before. The selected sectors popped up automatically, so the respondent could easily assess the types of knowledge required for each of the sectors mentioned by him/her.

In table 8 the mean importance value of each type of knowledge is presented for all economic sectors that were indicated by the respondents. The mean value has been calculated from the individual assessments of all respondents.

According to the respondents scientific knowledge is most important in 'pharmaceuticals', 'coke, petroleum products, nuclear fuel', 'general research and development', 'aircraft and spacecraft', 'rubber and plastic', 'medical, precision and optical instruments, watches, clocks' and 'recycling' (mean importance value greater than 4). It has little relevance in 'publishing, printing', 'construction', 'trade and repair', 'tourism', 'financial intermediation', 'real estate and renting services', 'business services' and 'public administration' (mean importance value smaller than 3).

Applied technical knowledge for technology development and product/process innovation is generally seen as more important. In as many as 21 sectors the mean value of importance is greater than 4, and only once ('real estate and renting services') it is less than 3. There are almost no sectors where this type of knowledge scores low. The differences between sectors are rather small regarding applied technical knowledge. This is quite similar in the case of high-quality higher education.

3.5 Story-lines linking challenges, sectors, barriers and policies

3.5.1 Education and training: Improving generic skills and improving the system to absorb cross-sectoral knowledge

The highest ranked challenge of 'education and training' was selected as starting point for several story-lines developed at the local focus-group workshops. Education and training is a challenge that it is crucial to address by improving the quality of the education and training system itself. But education and training is at the same time seen as an answer to address a wide range of problems like accelerating process and product innovation in traditional sectors, integrating new knowledge into other sectors (alongside ICT especially integration of new materials into traditional sectors), realizing sustainability goals etc. The further development of the education and training system with regard to generic ICT skills is still a major issue across different regional types.

Alongside unsurprising story-lines to increase the share of people with higher education in general, to address the problem of a shrinking labour force by increasing the education and training system, and to turn one's attention to the issue of education and training in the health sector to take care of this growing share of elderly, there are some interesting storylines addressing cross-regional and cross-sectoral issues.

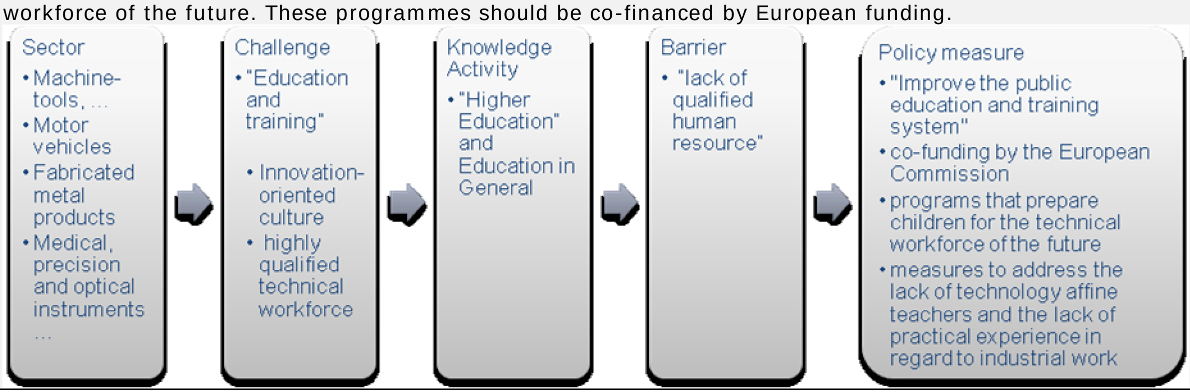
Education and training plays a major role for process innovation as well as for product innovation. Education and training is seen as the crucial factor for the integration of new technologies into traditional sectors and processes. Examples can be found in the area of cross-sectoral issues like linking the sectors of textiles and chemicals for products strengthened with fibres or to address environmental problems by an increase in recycling (see below).

> Knowledge absorbing regions: Education and training for process innovation and product innovation in traditional sectors
>
> Sector: Products strengthened with fibres (linking textiles and chemicals)
> Challenges: Education and training
> Knowledge activity: Higher education
> Technology: One of the most promising technologies for which firms from different sectors share a specialized competence and expertise is "layer-technology".
> Barriers: Lack of qualified human resources
> Policy measure: Improve the public education and training system

> Skilled industrial Eastern EU regions: Education to extend the recycling sector and to address environmental problems
>
> The third most important challenge is 'education' meant as dissemination of knowledge to the local societies. Participants claimed that such a process must be conducted in a highly innovative way in order to attract and eventually convince people to participate in implementing actions. Promoting knowledge and necessity for pro-environmental behaviour would result in more effective ground-level actions such as recycling bins, using ecological shopping bags etc. Two barriers seriously hampering the success in this field are identified: 'lack of qualified human resources' and 'insufficient quality of government services'. They are easy to explain as they are similar to previous barriers: the inadequately serious approach of local authorities to environmental issues.

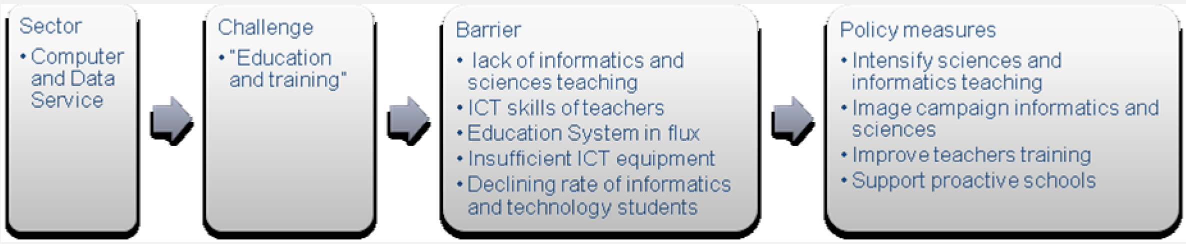
Moreover there is a major role and need for innovation-oriented education and training starting at primary school level.

> Skilled technology regions: Innovation-oriented culture to ensure the technical workforce of the future
>
> Education and training is crucial with regard to an innovation-oriented culture to ensure a highly qualified technical workforce for the future. Researchers and innovators are not serving as "heroes" for the young generation, there are no scientific role models for them (or rather they do no chose scientists as role models), there is a lack of technology-affine teachers and also a lack of practical experience with regard to industrial work.
>
> According to this view the lack of qualified human resources in 2020 is a major barrier to technological change and innovation for regional development. There is a need for measures to improve the public education and training system especially to address the lack of technology-affine teachers and the lack of practical experience with regard to industrial work and programs that prepare children for the technical workforce of the future. These programmes should be co-financed by European funding.



The need for policy measures to improve teachers' training and to improve the image of science and scientists is also addressed in a story-line with regard to High-tech regions in particular for the sector "computer and data services".

High-tech regions: Challenge "Education and Training"



Regarding ICT skills and literacy, the so-called digital natives, the next generation of labour force, might bring in innovative use of ICT and information systems like social software, but we need to guarantee that they also have business-relevant skills.

Education and training is seen as a tool to integrate new knowledge and new technologies into traditional sectors and their products. Improving the system of education and training is also seen as background and basis to address other major challenges like employment, environmental problems, energy security and renewable energy sources and sustainability in general.

The challenge of employment was only in the Traditional Southern EU regions seen as a problem of future unemployment. In the other story-lines the challenge of employment is seen as a problem of qualified staff in the future.

3.5.2 Sustainability – How to turn knowledge into business creation

Particular environmental challenges are driving forces for the transformation of important sectors within the regions and the integration of new technologies.

One example for this is waste management, where one story-line (from a metropolitan region) addresses the question how to transform expertise into firm creation.

Metropolitan knowledge-intensive services regions: How to turn knowledge into business regarding environmental challenges

Sustainability may hamper firm activity, and more strict environmental regulations could lead to a smaller number of firms. But it can also create innovations and business activity, but this is difficult to achieve. E.g. we have much attention for waste management, but we do not know how to best transform expertise into firm creation. Basic research and science and applied research activities are needed to develop new production techniques (which e.g. will use existing energy sources more efficiently) and can as such create new firm activities. Public (co-) investments can support such activities, e.g. regarding alternative energy projects.

With regard to environmental challenges public funding plays a major role not only in the way to generate the knowledge but also to turn knowledge into stable business activities. In some cases sustainability projects like using geothermal energy for the greenhouses are organized by the sector itself, but public support is often needed to lower the first risks of private investments. One example from a Metropolitan KIS type of region was the use of water technology from TU Delft in relation to the expected rise of the sea level due to climate change. Publicly funded tests and demonstrations are expected to support the valorisation and use of such new technologies.

Another story-line addresses the issue that public funding is needed to turn knowledge of energy-efficiency into export products.

Metropolitan knowledge-intensive services regions: Turning knowledge of energy-efficiency into export products Challenge: More energy-efficient production process Knowledge activity: Applied technology Policies: Pilot projects for testing new technologies (which, if successful, can even be turned into an export product)

One of the story-lines is addressing the need for intermediaries to act as providers of knowledge and technology transfer with regard to the environmental challenges.

Traditional Southern EU regions: Environmental preservation, process optimization and new products development as key elements to deliver healthy and safe food which satisfies the variety of requirements from a more and more demanding consumer The food products, beverage and tobacco sector is expected to be a key economic factor for the regions of Valencia and Andalusia (Type 7). Sustainable development and environmental protection, together with water resources are expected to be among the main challenges that the sector will have to face in the coming future in order to cope with food legislation and consumers' demands. Food safety and traceability issues are thought to become key factors, if the sector wants to stay competitive in a global market. Migration will bring new consumers, and this will boost new product developments specially designed to satisfy their needs. Limited production, transfer and use of knowledge and the lack of risk capital are believed to hamper the evolution of the sector. The establishment or promotion of intermediaries which can support knowledge and technology transfer, together with the development of a legal framework which is more research- and innovation-friendly are believed to be the way to overcome these barriers.

Across different types of regions and with regard to a wide range of sectors, the issue of embedding the knowledge on sustainability further into business practices is central.

3.5.3 Service sectors – need for coordinated governance

The discussion of crucial changes for the future development of regions in the EU on the focus group workshops shows that the sectoral mix of industries today matters strongly. But especially the new service sectors need new forms of coordinated governance. This was raised in the focus group discussion with Metropolitan KIS regions in the Netherlands, where policy harmonization of different spatial dimensions is regarded as a crucial point for the development of the creative industries.

Metropolitan knowledge-intensive services regions: Policy coordination for the creative industries Challenge: Difficult to start clusters or network initiatives Barrier: Too many different administrative layers (and subsidy flows); too fragmented and diversified Policy: More harmonization of local, regional and national policy initiatives

The need for policy coordination is also addressed with regard to "traditional" service sectors. While the scope and pace of innovation in high-profile medical technologies is widely addressed, innovation and innovation processes in healthcare services still need to be addressed. To promote the diffusion of innovation in health care organizations a better coordination between innovation policies and healthcare policies is needed.

Metropolitan knowledge-intensive services regions: Need for innovation in Healthcare services Challenge: Supply sufficient healthcare services to an ageing population Knowledge activity: Applied technology, ICT, organisational innovations Barrier: Insufficient skilled people, institutional structure (fragmented policies hampering innovation) Policies: Spend more on co-funding applied research and innovation projects, support the networking between relevant agents within and outside the region, promote information and communication technologies, coordinate the regional research technology and innovation policy better with national and European RTI-policies

With regard to the sector 'health & social work' there is a growing need for elderly care services and at the same time a lack of staff in elderly care. Unlike the other sectors, the growing need for elderly care services does not imply a growth market but an increasing demand for public services, and therefore the growing importance of the sector stands for a growing need for public financing. The implementation of technological innovation in the workplaces in elderly care services is usually low/slow, the work environment is often not beneficial to the employees' health (lack of technologies to support carrying heavy stocks/persons) and to long-term employability. Measures to stimulate the demand for innovation-oriented public procurement could address these problems by supporting R&D in the sector of medical and care equipment. In this case there is also a need to establish relations between different policies.

Cross-sectoral issues – especially an innovation-oriented culture in Europe – are emphasized. Therefore there is also a need for a broader scope of European structural policy and its measures with regard to an innovation-oriented culture. Furthermore, for many issues there is a need for inter-departmental coordination and governance at the national and European levels to address cross-sectoral innovation.

3.6 Testing statements on the 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 were to be tested by formulating them as statements and asking the respondents to the survey whether they agree with them or not: "In the following we present some statements on the future impact from research, technology, innovation and education on regional development in Europe until 2020. Please indicate for each statement whether you agree with it or not!"

In general, agreement is quite high. To almost all of the 14 statements more than half of the respondents agree. Only the statements 3, 6 and 13 receive a lower agreement than 50% (see table 5.6 in main text). It is particularly contested that metropolitan regions will not only lose their manufacturing sector but also 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 patents and high-tech services will become the primary way of diffusing new knowledge at the expense of trading new products. On the contrary, several statements receive very strong agreement (more than two thirds of the sample). This applies to the statements 1, 4, 5, 7, 9, 10, 12 and 14. The highest rates of agreement receive statements 10 - stressing the importance of innovative high-tech companies in addition to universities - and 5 - stressing the importance of education for establishing high-tech manufacturing in low-income regions. In the case of several statements a share of respondents that is not negligible was not able to assess them. In the case of the statements 11 and 13 more than 20% answered "don't know", in the case of the statements 2, 3, 6, 8, 9, 12 and 14 this share is still more than 10%.

Table 10 gives an overview of the rates of agreement by type of region.

Table 10 Share of 'Very important' agreement to STATEMENTS ON THE FUTURE IMPACT OF RTI on regional development

	All regions	Metropolitan knowledge-intensive services regions	Knowledge absorbing regions	Public knowledge centres	Skilled industrial Eastern Europe	High-tech regions	Skilled industrial technology regions	Traditional Southern Europe
10: 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	78.4	63.6	80.0	75.7	82.1	89.3	86.7	69.7
5: Education is the driving or catching-up factor for high-tech manufacturing in low income regions	74.5	63.6	73.3	75.7	80.4	78.6	84.0	57.6
7: Accessibility will remain important for regions in developing knowledge intensive services	70.2	52.7	71.1	70.3	69.6	71.4	84.0	66.7
9: There will be increased competition between high income regions for attracting students and creative knowledge workers	70.2	58.2	60.0	64.9	73.2	78.6	84.0	66.7
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	58.2	64.4	67.6	78.6	75.0	78.7	54.5
12: Regions with a strongly developed government research sector need to strengthen local private R&D-activities to improve their economic performance	67.8	56.4	68.9	56.8	69.6	75.0	80.0	60.6
1: Services will remain the primary drivers of employment growth	67.5	60.0	71.1	67.6	71.4	71.4	65.3	69.7
4: Business R&D and patents will remain the drivers for high-tech manufacturing in high-income regions	67.5	56.4	66.7	73.0	62.5	71.4	80.0	57.6
8: Universities will be the main driver for knowledge int. services	55.3	49.1	46.7	48.6	71.4	46.4	65.3	42.4
11: Southern European regions need to strengthen their knowledge absorption and diffusion capacities by intensifying their investments in secondary and tertiary education	53.5	38.2	48.9	43.2	51.8	35.7	76.0	63.6
2: More medium-high-tech manufacturing will move from the central parts of Europe to Eastern Europe	51.4	43.6	42.2	48.6	64.3	46.4	54.7	54.5
6: The long term and EU-wide trend of de-industrialisation (shrinking share in employment) will continue	43.8	47.3	42.2	43.2	42.9	42.9	41.3	48.5
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	43.6	40.0	21.6	46.4	35.7	38.7	36.4
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	20.0	28.9	29.7	42.9	21.4	22.7	36.4

In the case of almost all statements the agreement of respondents from Metropolitan knowledge-intensive services regions is clearly lower than in the whole sample. Only in the case of statement 13 the agreement is clearly higher. This is especially interesting in the case of statement 3 which refers explicitly to metropolitan regions, regarding the disappearance of manufacturing and associated business-R&D from metropolitan regions. Respondents of this type of region agree to this statement even less than the respondents of all other types, where the agreement is already low. The only types where the rate of agreement is a bit higher (but still well below 50%) are the Skilled industrial Eastern EU and the Traditional Southern EU regions.

The agreement of Knowledge absorbing regions is clearly lower than in the whole sample in the case of several statements (2, 8, 9 and 11) and never clearly higher. This is similar in Public knowledge centres: Here in five cases (statements 8, 9, 11, 12 and 13) the agreement of respondents is clearly lower than in the whole sample and only once (statement 4) it is clearly higher.

In many cases the agreement of Skilled industrial Eastern EU regions is clearly higher than in the whole sample. This is true of statements 2, 3, 5, 8, 13 and 14. Only in one case (statement 4) it is clearly lower. Two statements (2 and 14) specifically refer to this type of Skilled industrial 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 of regions. 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 EU regions is even higher.

In high-tech regions the results differ from the whole sample. To statements 9, 10, 12 and 14 the agreement of High-tech respondents is clearly higher than in the whole sample, to statements 2, 3, 8 and 11 it is clearly lower. The quite provocative statement that patents and high-tech services will become the primary way of diffusing new knowledge at the expense of trading new products (statement 13) explicitly refers to High-tech regions. The rate of agreement to this statement is even slightly lower than in the whole sample.

The respondents of Skilled technology regions agree to most statements more often than the whole sample. Only in the case of statement 3 the rate of agreement is clearly lower.

Respondents from Traditional Southern EU regions show a somewhat extraordinary pattern of agreement. This is especially true of the comparatively high agreement to statement 1 - services as primary drivers of employment growth - (ranking top together with statement 10) and the relatively low agreement to statement 5 - stressing the importance of education for establishing high-tech manufacturing in low-income regions (ranking only seventh). Most often the agreement of respondents from these regions is clearly lower than in the whole sample. Only to the statements 3 and 11 the agreement among Traditional Southern EU regions is 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 in other types.

3.7 Lessons from the Foresight for regional policy

The most important regional policy issues with a particular focus on research, technology and innovation that came up in the Foresight exercise are:

Education: Education and training is one of the top challenges in all regional types. Improving the public education institutions is mentioned by the respondents of all types as one of the top policy priorities. It is even one of the most frequently mentioned sectors that will be important for future regional development in five of the seven types of regions. 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, disregarding low or high income levels. A quite remarkable result in this context is that the rate of agreement is comparatively lowest in the lagging economies in Traditional Southern EU regions. In the focus group workshops a frequently addressed barrier is the lack of qualified human resources, explicitly discussing it in the context of education and training. Given the long-term perspective of the Foresight exercise, policy measures are not only related to tertiary education including local tertiary-education infrastructure (universities specialized on sectors of strategic importance for the region), in order to avoid the outflow of young potentials, but also to the training of skilled and unskilled people. The discussions also show the need for additional skills and specific education to avoid one-sided specialization, and to promote multi-disciplinary and cross-sector linkages. This was raised in the focus group discussion in High tech regions referring to the so-called "digital natives" who would need business skills too in order to perform well. In the Austrian workshop addressing Skilled industrial technology regions, it was also argued that raising awareness for technology oriented careers should start already at the level of primary schools. The focus group workshops reinforce the impression of the importance of education for regional development. The challenge of ‘unemployment’ is mostly interpretated in terms of the need to secure a sufficient supply of adequately skilled workforce. Only in the Spanish workshop this challenge was explicitly linked to the reduction of unemployment.

The Foresight shows that education is obviously one of the top RTI-issues in almost all types of regions, being a general policy task at the European level. Nevertheless, it has to be expected that there are differences between the regions regarding the part of the education system where improvements are most necessary. There is fragmentary evidence from the focus group workshops that the need for improving education institutions can concern different levels - secondary education, tertiary education, vocational training - in different regions.

Applied technology development and innovation: In all types of regions, and most sectors, applied technology development and innovation is seen as important for future regional growth; more important than scientific, basic research. The importance of applied RTDI for regional development is clearly a cross-sectoral issue. It is seen as a generally important activity for increasing the competitiveness of the regional economies, but it is also stressed by many experts that R&D is not sufficient. Especially not for service oriented sectors and region. E.g. especially in the Metropolitan KIS regions it is stressed that while R&D is still an indispensable input, it is not the only means to raise innovativeness and productivity. The foresight shows that especially the importance of applied research and innovation (and policy measures addressing this) is widely appreciated.

Similar to education, applied R&D and innovation is an important issue across all European regions. Again support measures will have to be specified according to the particular differences between regions and types of regions regarding the most needed knowledge inputs and institutional improvements. The most remarkable differences between regional types (according to the survey) can be found with regard to two RTI-barriers and one policy measure aiming at improving the RTI-infrastructure: The barrier 'lack of R&D-infrastructure' seems to be much more important in Skilled industrial in Eastern EU regions, than in all other types. On the contrary, it is hardly a barrier at all in High tech regions. A weakness to exploit the potential of ICT (barrier 'limited use of ICT') is a particular problem in the Traditional Southern EU regions. In all other types there is also room for improvement, but it is rarely seen as a serious deficiency. The need for extending or improving the system of technology intermediaries like technology centres is strongly indicated only in Skilled industrial Eastern EU regions. In all other types, obviously, the demand for such institutions has more or less been satisfied.

Sectors and technologies of the future: The discussion of the most important economic sectors for the future development of the respective regions leads to the conclusion that the past development and the existing sectoral mix of industries of today, matter strongly for the future. In most workshops the selection of the most promising sectors is obviously based on the specialization that has emerged until today. New potentials of development, going beyond the present sectoral and technological specialization, are well seen, but they are based on the accrued experience in the region. It seems that it is hardly possible to define them across all European regions or even across all regions of one type. The most important sectors for the future development of regions can also be triggered by particular environmental challenges. An obvious example for this is the challenge of scarce water resources. This challenge is clearly specific for Traditional Southern EU regions.

Policy measures aiming at the support of specific economic sectors that seem to have future growth potential are very much the task of individual regions. Of course, several regions will share similarities in this respect. In some cases - maybe reacting to geographically broader challenges like scarce water resources - certain sectors of the future might be the same in most regions of one type. But in general, the similarities will probably not apply to whole types of regions. The particularity of sectoral specialization at the level of regions does not imply that there are no super-regional processes underlying regional development almost everywhere. This applies primarily to some generic technologies (e.g. ICT, software, new materials, biotechnology) which are crucial inputs to a wide range of new emerging cross-sector specialisations. These fields of so-called 'General Purpose Technologies' are actually global and have therefore to be absorbed more or less in all European regions and in many sectors.

Cross-sector collaboration in RTI-processes: Collaboration is generally seen as very important. But it is also often argued that it is done anyway without a need for further support. Therefore it does not show up in some regions as an actual barrier (especially Metropolitan KIS and High-tech regions). This leads to the conclusion that the best performing regions are less concerned about a lack of collaboration. The need for cross-sectoral collaboration is stressed more than the need for inter-regional collaboration. This is in line with the importance of emerging new sectors which is often based on the combination of specific activities in traditional sectors and the integration of new fields of technology.

Policy measures aiming at cross-sectoral collaboration seem to be very important both at the regional level, where the particular networks of the specialized sectors of individual regions can be supported, and at the European level, where generic technologies are going to be developed. The survey shows that the type-level might matter more in two other aspects which are related to the topic of collaboration: developing regional RTI-strategies and coordinating RTI-policies at different levels of governance. The need to run a coordinated process to come up with an RTI-strategy at regional level is strongly indicated in the Traditional Southern EU regions. But not only there; it is also frequently indicated in the Skilled technology regions and Skilled industrial eastern EU regions. The policy measure 'coordination of RTI-policies of regions, countries and the EU' is appreciated particularly in Skilled technology and Traditional Southern EU regions. It might come as a surprise that the need for a better coordination of regional, national and EU RTI-policies is so strong in the Southern type where much of EU regional policy has taken place in the past decades whereas it is clearly less in comparison in Skilled industrial eastern EU regions where EU regional policy has started only rather recently.

The project shows that regional Foresight exercises have a high potential for linking technology and regional policies in Europe. Of course, Foresight processes need more time and resources than were available in this project. But we think that already the experience made in this project, limited as it is to types of regions, lets us expect that applying the full-scale Foresight methodology could help substantially to shape an innovation-oriented EU cohesion policy. A standard regional Foresight tool-box - where Delphi-surveys and focus group workshops are integrated in a process design with several feedback loops and which is based on a broad participation - would make it possible to organize Foresight processes in a wide range of EU regions in a comparable way, enabling learning from other Foresight activities and providing crucial information for EU cohesion policy.