ESPON

SIESTA
Spatial Indicators for a 'Europe 2020 Strategy' Territorial Analysis

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Annex C

Research and Innovation

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

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

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

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This basic report exists only in an electronic version.

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1. R&D Expenditures as % of GDP

1.1 Meaning of indicator

Research and development (R&D) activity is defined as “creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications" (OECD, 2002, para. 57). A high-level element of novelty or innovation distinguishes R&D from other similar activities. ‘Intramural expenditures’ or expenditures that occur within specific geographical areas, in this case NUTSII regions, are examined across all institutional sectors – the business enterprise sector (BES), government sector (GOV), higher education sector (HES) and private non-profit sector (PNP). Later maps focus exclusively on Business Expenditure on R&D (BERD) and provide interesting comparisons. **Map 2** illustrates the average total expenditure on research and experimental development, 2007-2010 expressed as a % of GDP. **Map 3** illustrates how far specific regions need to progress to meet or exceed their agreed national targets on % of GDP investment in R&D, and facilitates an examination of inter-regional disparities both at the national and transnational levels. **Map 4** illustrates trends in R&D investment at NUTS2 level from 2003 to 2010. This analysis identifies areas that are lagging in investment in real terms but also highlights areas with significant potential for development based on the magnitude of recent change.

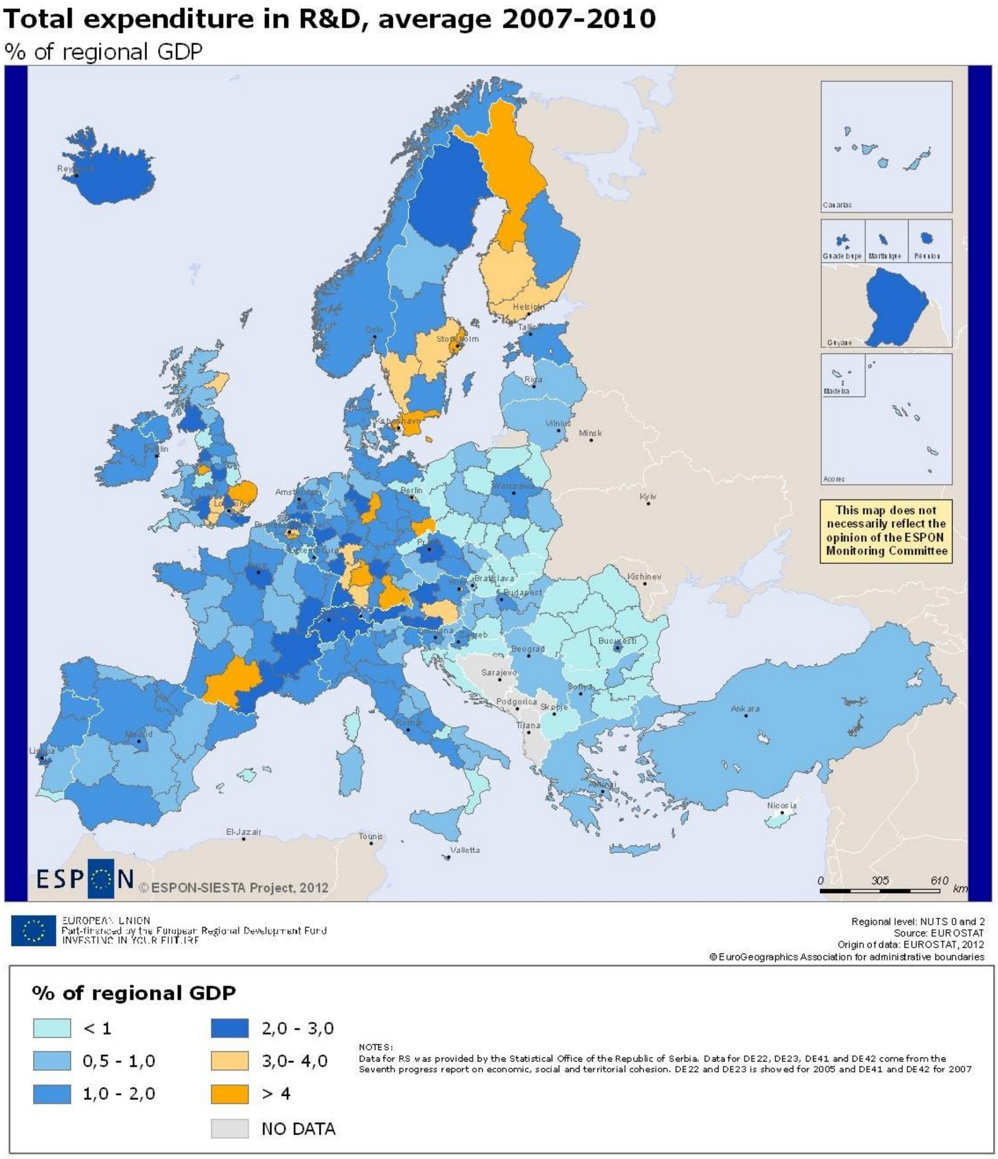
1.2 Relevance

Expenditure on R&D is considered an important input indicator of the innovative strength of any economy, increasingly important for global competitiveness. Innovation has also been identified in the EU2020 Strategy as one of the key activities that will help Europe emerge from the current economic recession. Within the Smart Growth pillar of the EU 2020 Strategy, research and innovation is one of three headline issues and investment in this activity is identified as an important aspect of an overall growth and jobs strategy. Combined with more efficient use of resources, innovation is seen as the key mechanism to make the European Union increasingly competitive over the coming decade and drive economic recovery. The Territorial Agenda highlights the importance of strong local economies in ensuring global competitiveness

(TA2020). To operationalise this aspiration, the Innovation Union flagship initiative has identified 34 action points that include goals towards improving the conditions and access to finance for research and innovation in Europe, and to ensure that innovative ideas can be turned into products and services that create growth and jobs (EU, 2010). Official documents like the Lisbon Agenda and Europe 2020 use %GDP investment in R&D as an important benchmark for knowledge-economy development policies (KIT, 2011, p. 21). Achieving the target of spending 3% of EU GDP on R&D by 2020 would induce the creation of 3.7 million jobs (An Agenda for New Skills and Jobs, Section 4.1) and contribute significantly to addressing a range of other goals in relation to inclusive growth.

The EU has set a headline target of 3% of GDP investment in R&D investment as part of the Smart Growth pillar of the EU2020 Strategy. Individual national targets have also been set, by a majority of countries, to recognise the variations across the European territory and these are outlined in the National Reform Programmes 2011. Most countries are beginning from a base well below the EU headline target and the examination of trends undertaken in Map 4 illustrates progress towards attaining the EU2020 headline target.

1.3 Percentage GDP investment in R&D



Map 2: Total Expenditure on R&D as % of GDP

Table 1.1 Regions with highest % of GDP investment in R&D

Member State	*Region*	*2007-2010 median*
Belgium	Prov. Brabant Wallon	7.26
Germany	Braunschweig	6.75
United Kingdom	East Anglia	5.85
Germany	Stuttgart	5.83
Finland	Pohjois-Suomi	5.63
United Kingdom	Cheshire	5.11
Denmark	Hovedstaden	5.10
Sweden	Sydsverige	4.75
Germany	Oberbayern	4.29
France	Midi-Pyrénées	4.20

Table 1.2 Regions with lowest % of GDP investment in R&D

Member State	*Name of region*	*2007-2010 median*
Macedonia	Former Yugoslav Republic of Macedonia	0.18
Romania	Sud-Est Romania	0.18
Bulgaria	Yugoiztochen	0.17
Spain	Ciudad Autónoma de Ceuta	0.15
Romania	Centru	0.15
Poland	Opolskie	0.14
Bulgaria	Severozapaden	0.14
Croatia	Središnja i Istočna (Panonska) Hrvatska	0.10
Poland	Lubuskie	0.10
Bulgaria	Severen tsentralen	0.09

Table 1.3 Regions closest to median % of GDP investment in R&D

Member State	*Name of region*	*2007-2010 median*
France	Lorraine	1.17
Italy	Provincia Autonoma Trento	1.17
Denmark	Sjælland	1.16
Denmark	Nordjylland	1.16
Germany	Schwaben	1.15
United Kingdom	Inner London	1.15
Poland	Mazowieckie	1.14
Belgium	Prov. Namur	1.14
Germany	Kassel	1.13
Germany	Sachsen-Anhalt	1.13

Expenditure on R&D is an indicator of the innovative capacity of any region. Innovation and creativity are two of the key drivers of the modern economy and have been identified by the European Union as important in emerging from the current economic recession and gaining global competitiveness, given the relatively higher labour costs in Europe relative to other regions of the world. However, one of the major challenges is that levels of investment in R&D in Europe are well below those in other regions, particularly Japan and Korea. The median level of investment in R&D in these countries from 2007-2010 (3.45% of GDP in Japan and 3.29% of GDP in Korea) was significantly higher than in the EU-15 (2.03% of GDP) and particularly the EU-27 (1.95% of GDP). Europe also lags significantly behind the US, which invested approximately 2.73% of GDP in R&D activities during the same time period. While Europe is generally ahead of the BRIC countries (Brazil, Russia, India and China) in terms of innovation performance, the European Commission Innovation Union Scoreboard shows that this lead is declining fast (Pro-Inno Europe, 2012, p. 9).

In 2007 only 19 of 287 NUTS2 regions met the 3% of GDP target established by the European Union (ESPON, 2010). Our data shows that while the EU has on average increased investment by 47.3% since then (2007-2010) only 28 NUTS2 regions now reach of exceed the headline target. The diversity across the European Union is significant. Two regions have achieved investment levels of more than twice the EU target, the Belgian province of Brabant Walloon and the Braunschweig regions in southern Germany that report average investment of 6-7% of GDP in R&D activities from 2007-2010. The former is primarily driven by the government and higher education sectors. The latter was German *City of Science in 2007* and is the location of important institutes such as the Johann Heinrich von Thünen Institute, until the end of 2007 named Federal Agricultural Research Centre, and the PTB Braunschweig that maintains the atomic clock responsible for the official German time (http://www.braunschweig.de/english/city/index.html). The NUTS2 regions that have already exceeded the EU targets are located in Sweden (4 regions), Belgium (2 regions), Germany (8 regions), Finland (4 regions), United Kingdom (6 regions), Austria (2 regions), Denmark and France (1 region each). There is a clustering of high-investment R&D regions around a number of important urban centres particularly the Malmo-Copenhagen corridor extending to Stockholm and encompassing most of Finland in the Baltic Sea region; an area in the south-east of England centred around London; the Midi-Pyrenees in southern France centred on Toulouse; two areas of Belgium around the capital region of Brussels (Nivelles, Flemish Brabant); the Stuttgart-Karlsruhe-Tubingen-Freiburg area, as well as major cities such as Dresden, Berlin, Munich in Germany and the regions of Vienna and Steiermark/Styria, all located in the Western Danube Space. Steiermark/Styria is Austria’s top engineering, science and research province and has developed three core competencies in mobility, health technology and eco-technology through a clustering approach. This has been facilitated by high-level research and educational infrastructure, attractive tax conditions for headquarters and R&D-activities, and attractive financial support programs especially for R&D (Regional Innovation Monitor, 2010) and the region is now one of the world’s leading cleantech centres. However, this has not necessarily had positive spin-off effects for the region, which has the second lowest level of income in the country (Statistics Austria).

In our analysis, a further 29 regions emerged with average investment in R& D of 2-3% from 2007-2010, primarily located in the NW Europe and the Western Danube Space. Switzerland is just below the EU target with an average investment of 2.99%. Other regions within this category included Paris and Eastern France, particularly along the Swiss border; seven German regions located primarily in the Western half of the country and including cities such as Cologne, Bremen, Hannover, Freiburg and Giessen; six regions in the United Kingdom including areas around Bristol, Bath, Luton, Derby, Nottingham, Blackpool and Glasgow); Lisbon area of Portugal; Iceland; Northern Sweden centred on the university city of Umea with a concentration of ICT and Biotechnology; Prague in the Czech Republic and its neighbouring region; three regions of Austria bordering Switzerland, Germany, Italy and Slovenia; as well as a Belgian-Dutch corridor from Antwerp to Utrecht and taking in the Dutch region of Noord Brabant (Tilburg, Eindhoven, Breda). Of those regions, for which data was available, 230 regions do not currently fall within a 1% window of the EU2020 target for investment in research and experimental development.

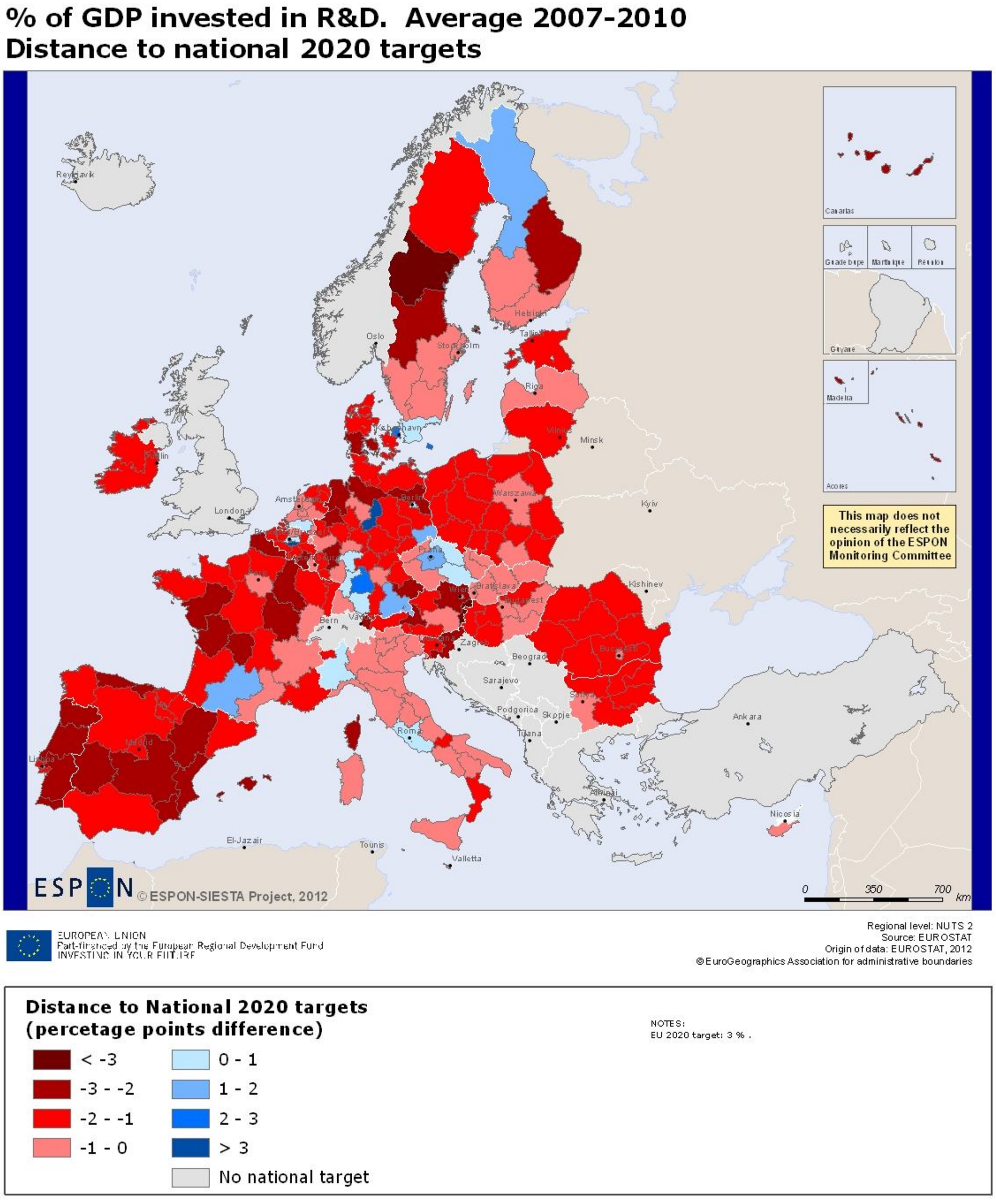
While many cities provide the focal point for R&D investment across Europe, there is not necessarily a link between metropolitan areas and investment. For example, in the northern Baltic Sea region, Pohjois-Suomi has the 4th highest investment in the entire European space but is a predominantly rural, remote region. While there are exceptions and some evidence for smart, rural regions within Europe (ESPON, 2010b) the areas that have low investment tend to be predominantly rural regions – some close to a city, others remote. This may be due to a restricted labour pool, less opportunity for agglomeration, a predominance of more traditional economic activities such as agriculture and tourism and issues of accessibility. For example in central Spain and western France, there are bands of relatively low investment in R&D and these correlate with predominantly rural spatial characteristics. Low levels of R&D investment in Europe occur in SE Europe (Romania, Bulgaria), the Western Balkans (Croatia, Macedonia), and parts of the Mediterranean basin including Turkey, the southern tip of Italy and Corsica. The lowest levels of investment have taken place in the outermost regions including the Acores, Madeira, Canarias and Ciudad Autónoma de Ceuta.

Two interesting patterns emerge from the analysis:

- Relatively high-performing regions are developing across national borders and between major urban regions. This is particularly evident in the Malmo-Copenhagen corridor (among the highest performing regions) and in the category of regions that have averaged 2-3% of GDP investment over our study period. Two particular examples are the Antwerp-Utrecht corridor noted above and also a band of investment from SE France through Switzerland into Austria and Southern Germany (the Great Region and Upper Rhine regions). Complementarity and the development of synergies across borders may play a key role in further innovative development. These two functional regions within the Western Danube space have been identified as important cross-border metropolitan areas with significant development potential and a series of policy recommendations to further this potential have been made in the METROBORDER project (METROBORDER, 2011). The challenge will be to put in place appropriate governance arrangements to facilitate continued cross-border metropolitan growth and ensure balanced spatial development. While R&D investment is high in these areas, potential spin-offs to neighbouring regions are not occurring and this is a particular feature of spatial development in Central and Eastern Europe (FOCI, 2010).

- Some areas of very high R&D investment directly border areas of the lowest investment. In the United Kingdom for example, the region of Shropshire and Staffordshire directly borders a region of very high investment in Cheshire. A similar pattern is evident across the German-Czech border where Severozápad with an average investment of 0.28% of GDP is directly adjacent to Dresden that had an average investment of 4.08%, one of the highest in Europe, from 2007-2010. This may be a result of either effective clustering which puts neighbouring regions at a significant disadvantage or it may be that these areas are predominantly rural areas acting as a buffer to more economically developed regions. However, the potential negative impacts of clustering should be considered.

1.4 Regional R&D investment compared to national targets



Map 3: % GDP investment in R&D to national targets

Table 2.1 Best performing regions in % GDP R&D investment compared with national targets

Member State	*Name of region*	*% above target*
Belgium	Prov. Brabant Wallon	4.26
Germany	Braunschweig	3.75
Germany	Stuttgart	2.83
Denmark	Hovedstaden	2.1
Finland	Pohjois-Suomi	1.63
Czech Republic	Střední Čechy	1.62
Czech Republic	Praha	1.51
Germany	Oberbayern	1.29
France	Midi-Pyrénées	1.2
Germany	Dresden	1.08

Table 2.2 Poorest performing regions in % GDP R&D investment compared with national targets

Member State	*Name of region*	*% below*
Spain	Ciudad Autónoma de Melilla	-2.73
France	Corse	-2.76
Spain	Ciudad Autónoma de Ceuta	-2.855
Portugal	Região Autónoma dos Açores	-2.88
Sweden	Småland med öarna	-2.88
Portugal	Região Autónoma da Madeira	-2.9
Portugal	Algarve	-2.93
Austria	Burgenland (A)	-3.14
Sweden	Mellersta Norrland	-3.25
Finland	Åland	-3.80

Table 2.2 Median performing regions in % GDP R&D investment compared with national targets

Member State	*Name of region*	*% below*
Poland	Pomorskie	-1.16
Poland	Łódzkie	-1.18
Poland	Wielkopolskie	-1.18
Germany	Oberpfalz	-1.19
Poland	Lubelskie	-1.19
Belgium	Yuzhen tsentralen	-1.21
Germany	Thuringen	-1.21
Hungary	Nyugat-Dunántúl	-1.225
Denmark	Midtjylland	-1.26
Hungary	Közép-Dunántúl	-1.265

In general terms, Map 3 illustrates the distance that each region has to go to reach national targets. This discussion focuses on the countries that have established targets, and excludes the UK, Greece, Switzerland, Iceland, Norway, Western Balkans and Turkey where no specific national target has been set. Although an overall target of 3% of GDP has been set for the European territorial area as a whole, national targets vary significantly from a low of 0.5% in Cyprus to a high of 4% for Sweden and Finland, countries that are already investing heavily in R&D activities and have been identified as 'Innovation Leaders' (Pro-Inno Europe, 2012, p. 9). It would appear that those with an initial advantage in terms of R&D wish to ensure that this relative position is maintained while others with more traditional or low-tech economic structures have set less ambitious targets. The variation in national target levels is important to bear in mind when interpreting the map.

Of the 225 European NUTS2 regions for which data was available, only 21 have already exceeded their national targets. The three regions that have furthest exceeded their national targets (3%) are those that already have the highest levels of investment in R&D, Prov. Brabant Wallon (in Belgium) and Braunschweig and Stuttgart in Germany. Map 2 illustrates a significant concentration of investment in R&D in the Baltic Sea region, particularly in Finland and Sweden. However, these countries have set themselves more ambitious national targets of 4% explaining the facts that only one region from these countries – Pohjois-Suomi – appears in the top

10 list of those exceeding their target and that three regions appear in the list of those furthest from achieving national targets. As the Tables also demonstrate, two regions in the Czech Republic appear as high achievers in relation to their national targets - Střední Čechy and Praha. Given that the Innovation Union scoreboard has identified the Czech Republic as a 'moderate innovator with a below average performance' (Pro-Inno Europe, 2012, p. 27), this is surprising. However, the tables mask the fact that the Czech national target is just 1% of GDP, significantly below all other national targets with the exception of Slovakia (also 1%) and Cyprus. This may be due to a tradition of manufacturing and heavy industrial activities in the eastern Danube space and a tourism/agriculture focus in Cyprus for example, neither of which support an innovation base from which more ambitious targets might be achieved.

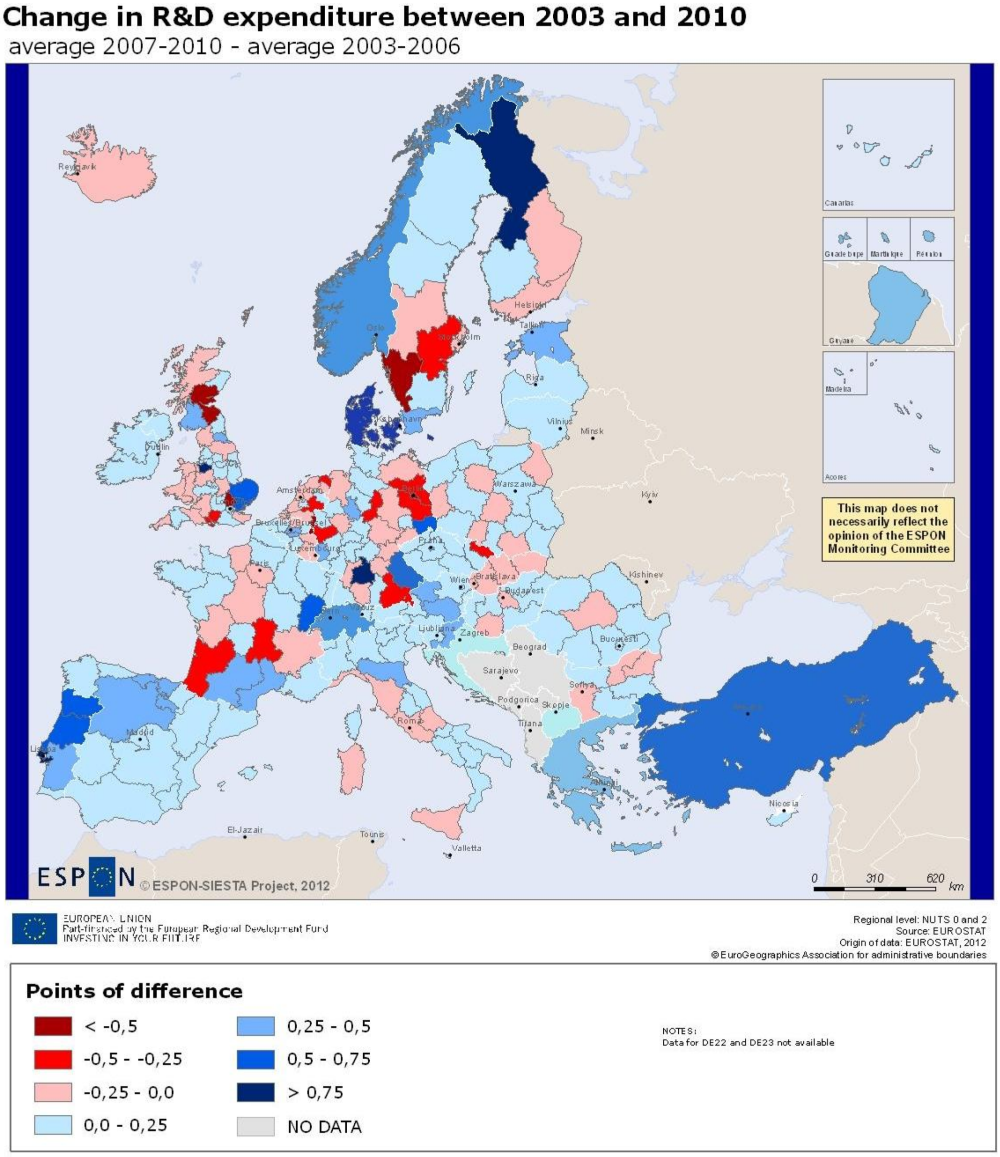
In general, parts of NorthWest Europe appear to have the furthest distance to go to reach national targets but these also correlate to predominantly rural regions that may have an economic base specialised in agriculture, tourism or other such activities. Similarly the outermost regions of Europe including Região Autónoma da Madeira and Região Autónoma dos Acores in the Atlantic, as well as Ciudad Autónoma de Ceuta and Ciudad Autónoma de Melilla in North Africa score very poorly in relation to national targets but their relative isolation in terms of physical location is most likely the explanatory factor. Ciudad Autónoma de Ceuta is also a tax haven, focusing more on knowledge-intensive activity and it is unlikely that it will develop any significant R&D capacity. In the Northern Periphery, greater distance from national targets for investment may be explained by the physical landscape. For example, Mellersta Norrland in Sweden is a mountainous region while Åland in Finland in an island region off the south-west coast, both remote regions that are potentially unattractive to and unsuitable for R&D activities.

The issues that our analysis raises include:

- How useful are national targets? It is clear that there are distinct regional as well as national variations in terms of R&D across the European territorial area and it may be that regional targets are more appropriate than national targets. Weaker areas could be potentially disadvantaged if national authorities focus on strengthening well-performing regions at the expense of 'lagging regions' in order to reach some national average that suggests success in meeting goals. This could potentially favour metropolitan regions that already benefit significantly from investment in R&D and advanced service activities (FOCI, 2010). It is important that a regional policy focused on increasing the R&D investment should take account of the strong heterogeneity across European regions and the need to adopt place-appropriate policies (Ortega-Argiles et al., 2012).

- Areas of relatively poor performance are in close proximity to very successful places, demonstrating again that spillover does not necessarily occur. For example Burgenland is furthest away from Austrian national targets yet it is located adjacent to Steiermark/Styria, the most innovative region in the whole of Austria and a European leader in innovation. Burgenland has traditionally been a contested borderland with significant ethnic minorities, focused on agriculture and in particular viticulture. Historical contexts and path dependency are therefore important in understanding current patterns and the likely future trajectory of specific locations.

1.5 Change in R&D Expenditure, 2003-2010



Map 4: Change in R&D Expenditure, 2003-2010

Table 3.1 Regions with greatest positive change in R&D expenditure (as % of GDP), 2003-2010

Member state	*Name of region*	*Change (%)*
Portugal	Lisboa	1.19
United Kingdom	Cheshire	1.04
Finland	Pohjois-Suomi	0.90
Germany	Stuttgart	0.80
Germany	Dresden	0.75
United Kingdom	East Anglia	0.69
United Kingdom	Essex	0.60
Portugal	Centro (P)	0.60
Portugal	Norte	0.57
France	Franche-Comté	0.55

Table 3.2 Regions with greatest negative change in R&D expenditure (as % of GDP), 2003-2010

Member State	*Name of region*	*Change*
United Kingdom	Hampshire and Isle of Wight	-0.38
Germany	Oberbayern	-0.39
Netherlands	Gelderland	-0.43
France	Auvergne	-0.46
Germany	Braunschweig	-0.50
Germany	Berlin	-0.58
United Kingdom	Eastern Scotland	-0.58
Netherlands	Limburg (NL)	-0.59
United Kingdom	Bedfordshire and Hertfordshire	-0.73
Sweden	Västsverige	-1.88

Table 3.3 Regions close to median change in R&D expenditure (as % of GDP), 2003-2010

Member state	*Name of region*	*Change*
Hungary	Közép-Dunántúl	0.05
Latvia	Latvija	0.05
United Kingdom	Greater Manchester	0.05
Spain	Canarias	0.05
Poland	Lubelskie	0.05
Poland	Warmińsko-mazurskie	0.05
Bulgaria	Yugoiztochen	0.05
Austria	Burgenland (A)	0.05
France	Limousin	0.05
United Kingdom	East Yorkshire and Northern Lincolnshire	0.05

Identifying trends in R&D investment over time is a complex process and this is illustrated clearly in Map 4 and the associated tables. It is an important indicator of the overall economic health of a region given that the literature would suggest that investment generates information, which is subsequently transferred to knowledge and innovations that drive regional performance. From 2003-2010, the EU15 increased investment as a % of GDP in R&D by 0.13% while the EU27 increased investment by 0.10%. This is significantly behind the increases witnessed in both the US (0.15%), which is already ahead of European levels, and China (0.17%) in the same time period. A recent report by the European Commission has acknowledged that the innovation gap between the EU and the US and Japan is in fact widening and that China, India and Brazil have started to rapidly catch up with the EU by improving their performance 7 %, 3 % and 1% faster than the EU year on year over the last five years' (European Commission, 2012, p. 4). This could potentially undermine Europe's position globally and its attractiveness to foreign investors with detrimential consequences for growth and employment.

The general pattern across Scandinavia, Ireland, the Iberian Peninsula, Central Europe and Turkey is of increasing investment although at a very modest rate. 84/255 regions for which data were available showed either no change or a decrease in investment in R&D activities from 2003-2010. There are significant decreases in parts of NorthWest Europe especially in France, Germany and the Benelux countries as well as the Northern Periphery and Poland. Particular areas such as Eastern Scotland and Gelderland (Netherlands) show relatively high levels of dis-investment and this has compounded an already poor performance relative to the European average in these locations. For example, Eastern Scotland has moved from #123 in terms of median investment (2003-2006) to #217 in the period 2007-2010. Given that “R&D activities are essential for a region to be competitive, and be able to grow in a knowledge economy” (KIT, 2011, p. 49) this demonstrates a worrying trajectory for a number of regions, makes the achievement of a 3% of GDP target for investment in R&D more difficult to meet, and could contribute to polarization of employment opportunities.

The tables demonstrate that there is a significant performance gap opening up between regions. Unusually some countries dominate the league tables for both those with the greatest increases and decreases in investment. Areas that are already highly successful in terms of R&D capacity such as Stuttgart, Germany; Pohjois-Suomi, Finland; and Cheshire, UK (4th, 5th and 6th best performers based on median investment, 2007-2010) show high rates of overall increase in investment from 2003-2010. This may indicate a focus on consolidating R&D activity into specific locations as “returns to R&D (in terms of innovation performance) are likely to accrue in those regions where a critical mass of R&D efforts and investments is already concentrated” (KIT, 2011b, p. 29). For example, East Anglia and Essex, two regions adjacent to one another, are in the top 10 performing regions in terms of increased investment. These are also areas of very high Business Expenditure in R&D (see Map 7). There is a significant clustering of higher education (at least 7 universities including the University of Cambridge) in this area and the Cambridge Network (http://www.cambridgenetwork.co.uk/home/) is an important feature of this high technology region. The network links people from business and academia/research and supports the development of synergistic activities. This potentially speeds up commercialisation of innovation and reduces the “long time span needed to convert increases in valuable knowledge into economic performance” (García-Manjóna , J.V. & Romero-Merino, 2012, p. 1085). This kind of development and the importance of removing barriers to the commercialisation of innovations is a key priority of the Innovation Union (European Commission, 2012). Portugal emerges as the country that has increased spending on R&D most substantially with a 1.19% increase between 2003-2006 and the 2007-2010 time periods. While Lisboa ranks as the top region, two other Portuguese regions – Centro and Norte – emerge among the top ten regions of increase. There is a concentration of high and medium-high technology sectors in these regions but R&D activities focus primarily on innovation in transportation research, driven by a consortium of six educational institutions in partnership with private companies. While Portugal has demonstrated the highest increases, this has happened from a very low base of 1% of GDP or less and these regions remain significantly behind other European regions particularly those in the Baltic Sea region.

Many of the regions displaying the biggest decreases in expenditure are those that are already very successful. For example, Braunschweig and Oberbayern in Germany feature in the 10 worst performers in terms of negative change in investment, yet they remain amongst the most successful regions for R&D as demonstrated in Map 2. A potential explanation is that these regions already exceed substantially their national target of 4%, itself in excess of the EU headline target. It may be the case that increasing returns in innovation are unlikely from these regions and thus the focus of investment will move to other regions to bring them up to the same or similar levels. Potentially, this may indicate that Germany is adopting an equalisation or distributive approach to R&D investment, while the policy in other countries such as the UK and Sweden has polarised regional performance. For example, the greatest decreases in R&D investment from 2003-2010, are in Bedfordshire and Hertfordshire (UK) and Västsverige (Sweden), areas that are directly adjacent to the most successful regions.

The pattern of change in the Eastern Danube Space and SE Europe show a marginal increase in investment in R&D of about 0-0.25% on average. However, because previous levels of investment were very low, this apparently small increase actually represents a change of significant proportions. This is particularly the case for some regions in Poland, Bulgaria and Romania, which have among the largest changes in magnitude. Examples are Świętokrzyskie in Poland (160% increase), Yuzhen tsentralen in Bulgaria (107% increase) and Nordvest, Romania (104.9%). These regions still remain significantly below the EU target and lag behind Northwest Europe but if this rate of change were to continue, they would become among the top players in terms of %GDP invested in R&D within 20-25 years. Examining the data in this way generates an interesting prospect. Of those regions that have increased their performance by over 40% during the time period under examination, the majority are in the Mediterranean Basin and

Eastern Danube Space - specifically Estonia, Poland, Bulgaria, Romania, Turkey, Italy, Spain and Portugal - indicating a potential south and easterly shift in R&D activity in Europe in the coming decades.

2. Human Resources in Science and Technology

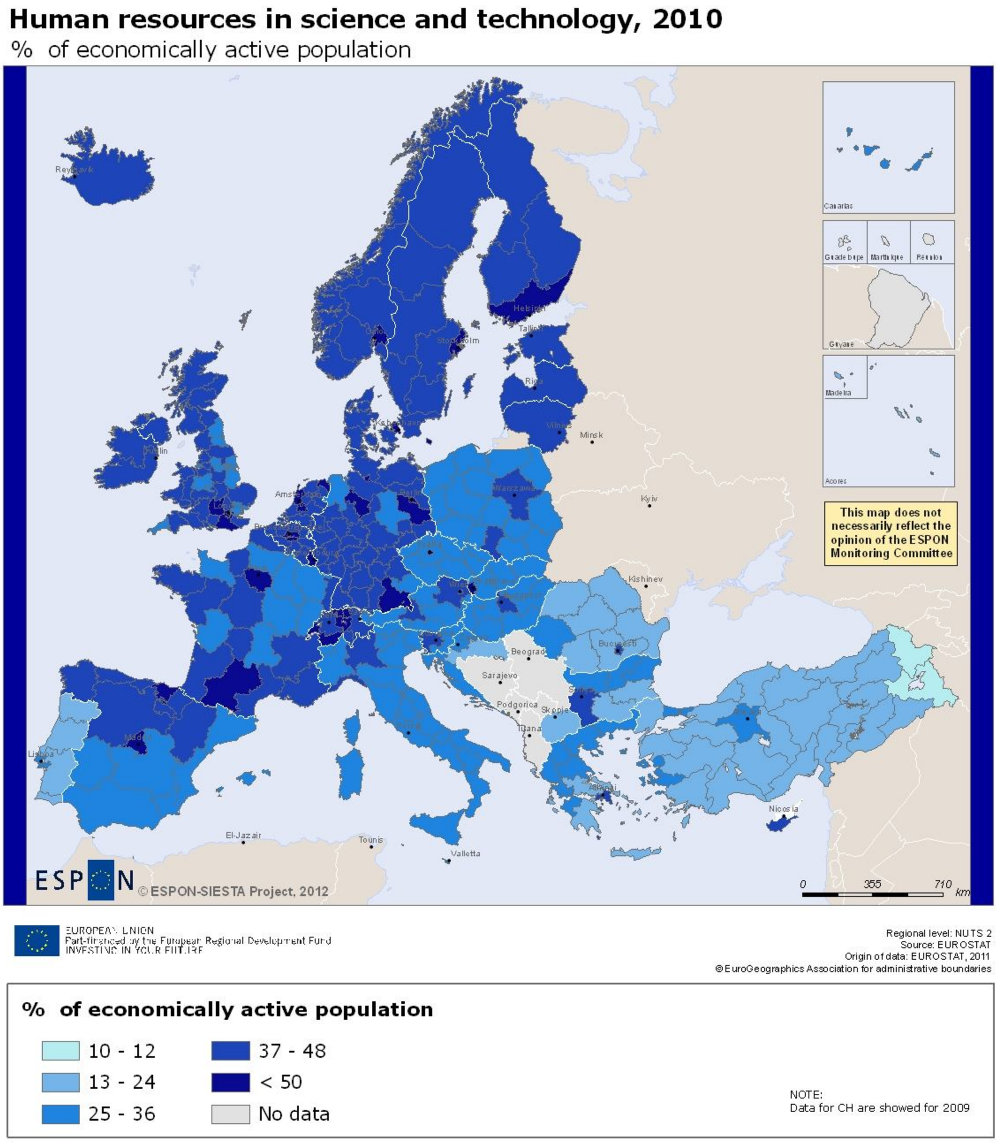
2.1 Meaning of indicator

Map 5 presents data from EUROSTAT on ‘Human Resources in Science and Technology (HRST)’ as a percentage of the economically active population of the NUTS 2 regions of Europe in 2010 (except for the Swiss NUTS 2 region, for which data are from 2009). In other words, it illustrates the distribution of the total workforce aged between 15 and 74, working in science and technology. These employees will normally have either successfully completed a third-level degree in science and/or technology or are employed in an occupation where a higher educational background is required. Values for this indicator are calculated using mostly the guidelines, concepts and definitions provided by the Canberra Manual of the Organisation for Economic Cooperation and Development (OECD, 1995).

2.2 Relevance

The Smart Growth pillar of the Europe 2020 Strategy provides an outline of what needs to be looked at, worked on, and strengthened in order to develop a European economy based on knowledge and innovation. The ‘Innovation Union’ flagship initiative is one of three key programmes that discuss in greater detail what the priority areas and targets are in order to achieve the EU 2020 Strategy’s smart growth objectives, alongside the industrial objectives set out by the flagship initiative on ‘Industrial Policy for the Globalisation Era’. Crucially, smart growth is based on the development and expansion of knowledge-intensive activities, including industrial activities, in which the human component remains fundamental. The Fifth Report on Economic, Social and Territorial Cohesion (2010) identifies innovation as important for all regions, whether or not they are currently research leaders. This means that understanding the distribution of human resources in science and technology (HRST) across European regions, as represented on Map 5, is a crucial first step in broadening scientific and technological innovation capacity. While the ‘Innovation Union’ communication highlights that “[...] a number of Member States are world leaders in manufacturing, creativity, design, aerospace, telecommunications, energy and environmental technologies” (EU, 2010, p. 6), this flagship initiative also attempts to put in place the necessary conditions to attract and retain talented researchers in the European Union. Map 5 illustrates the internal distribution of researchers within the EU and is an important indicator of innovation potential. Human capital is the key source of research and thus highly educated workers are essential to achieving smart growth objectives and remaining competitive vis-à-vis the US and Japan in particular (EU, 2010b). Mapping HRST at NUTS 2 level facilitates an assessment of the territories that need a continuous supply of HRST in order to remain Europe's innovation champions, and identification of those territories at the margins of Europe's smart economy that need targeted actions to overcome difficulties in developing knowledge-based activities (Territorial Agenda, 2020).

2.3 Percentage of Human Resources in Science / Technology



Map 5: Human Resources in Science and Technology, 2010

Table 4.1 European regions with the highest share of HRST in 2010

Member State	*Region*	*%*
United Kingdom	Inner London	66.9
Belgium	Prov. Brabant Wallon	61.0
Norway	Oslo og Akershus	59.5
Czech Republic	Praha	59.1
Sweden	Stockholm	58.4
Belgium	Prov. Vlaams Brabant	57.0
Switzerland	Zürich	56.8
Netherlands	Utrecht	56.7
Slovakia	Bratislavský kraj	56.6
Denmark	Hovedstaden	56.0

Table 4.2 European regions with the lowest share of HRST in 2010

Country	*Region*	*%*
Turkey	Malatya	14.6
Turkey	Mardin	14.3
Turkey	Manisa	14.1
Turkey	Erzurum	13.8
Turkey	Kastamonu	13.5
Turkey	Trabzon	13.0
Turkey	Gaziantep	13.0
Turkey	Hatay	12.5
Turkey	Van	11.9
Turkey	Agri	11.4

Table 4.3 European regions closest to median share of HRST in 2010

Member State	*Region*	*%*
France	Languedos-Roussillon	37.0
Austria	Niederösterreich	37.0
Germany	Chemnitz	36.9
Sweden	Småland med öarna	36.8
Spain	Ciudad Autónoma de Ceuta	36.7
Italy	Liguria	36.7
Austria	Salzburg	36.4
Germany	Münster	36.3
Latvia	Latvija	36.3
Italy	Lombardia	36.2

The industrial geography of the world economy has dramatically changed from the 1970s onward. Western Europe has experienced a marked deindustrialisation through the growing re-localisation of labour-intensive production to places where labour is cheaper, especially Latin America, Southeast Asia, North Africa and Eastern European countries following the fall of the Berlin Wall in 1989, the subsequent dismantlement of the Soviet Union, and the more recent integration of some Eastern European and Baltic countries into the European Union (e.g. Estonia, Lithuania, Latvia, Slovakia, Czech Republic, Hungary, Slovenia and Poland in 2004, Romania and Bulgaria in 2007). While an important part of Europe's labour-intensive industrial production has shifted eastwards, the industrial fabric of Western European and Scandinavian economies has not disappeared but, rather, is now increasingly dominated by science-and-technology-intensive activities. These are the areas of industrial production that are the most 'advanced', where added value is the most important, and which contribute the most to Europe's smart growth. Some regions of Europe are indeed world leaders in some areas of "manufacturing, creativity, design, aerospace, telecommunications, energy and environmental technologies" (EU, 2010, p.6) as the Innovation Union communication stresses, and are characterized by a high percentage of their economically active population classified as 'HRST', because they have completed a third-level degree in science and/or technology or are employed in an occupation where such an educational background is normally required. Although high-tech industries are major employers of HRST personnel, it is important to point out that HRST also represent an important proportion of jobs in some service activities.

As shown in the first table, at the very top of Europe’s regions with the greatest share of HRST as a percentage of their economically active population is Inner London (66.9% in 2010), which is made up of 14 districts: the City of London and 13 central boroughs, including Tower Hamlets, where Canary Wharf, London’s second financial centre, is located. The presence of these two global financial centres and their hosts of related activities – e.g. insurance, consulting, legal services, audit – is one of the main variables that explain such a high share of HRST in this NUTS 2 region. Although finance-related activities are classified as advanced producer services, they employ an increasing number of people qualified in science and/or technology, from computer scientists to network engineers, from mathematicians to database specialists. This is because the nature of financial activities has dramatically changed since the 1980s with the liberalisation of financial markets, the dismantlement of capital controls (in 1986 in the United Kingdom, UK), and the rapid replacement of traditional financial trading to computerised trading and the related growing importance of electronic equipment, algorithms for high-frequency trading for example, software, servers and datacentres, all designed, produced and managed by HRST people. The share of HRST in Inner London’s economically active population has grown from 51.4% in 2000 to 66.04% in 2010.. The importance of financial and finance-related activities as an element of understanding of high level of HRST in particular regions of Europe is also key to explain why Luxembourg – another European financial and banking hotspot – is in the top category in Map 5 as well, with 54.3% of HRST (compared to 36.2% in 2000), ranking 13th in Europe.

Another important explanatory variable underlying Inner London’s top position in this HRST ranking is the presence of several world-class universities and their associated research centres and spin-out companies in central London. Looking at Map 5, many capital cities and their metropolitan areas across Europe appear to benefit from the presence of large and/or world-class universities in explaining, at least partly, high shares of HRST in their economically active population – above 48% as per the map’s legend. In addition to Inner London, this is the case of the following NUTS 2 regions: Oslo og Akershus in Norway (59.5%), Praha in the Czech Republic

(59.1%), Stockholm in Sweden (58.4%), Bratislavský kraj in Slovakia (56.6%), Hovedstaden in Denmark (56.0%), Île de France in France (54.9%), Noord-Holland in The Netherlands (53.8%), Berlin in Germany (52.9%), Région de Bruxelles in Belgium (51.8%), Outer London in the UK (50.5%), Etelä-Suomi in Finland (50.2%) and Comunidad de Madrid in Spain (48.6%). These large urban or capital regions In Northwest Europe, the Northern Periphery and Atlantic Axis benefit from the presence of large pools of highly-qualified labour in science and technology, which are fundamental elements in the development and maintenance of economies of agglomeration. These are central to the consolidation of local and regional agglomeration economies, which thrive on high level of innovation triggered and sustained by knowledge exchange and production through the cross-fertilization of expertise, experiences and ideas, between HRST people. Encouraging and supporting concentrations of HRST to sustain agglomeration economies in strategic places in Europe should be a priority to develop and strengthen the innovation aspect of the Smart Growth pillar of the Europe 2020 Strategy, given that “regions highly endowed of human capital should keep this record in order to maintain their innovative performance” (KIT, 2011 p. 7).

A few other interesting features of the geography of high HRST regions in Europe are to be noted here. First, there is the fact that all Scandinavian regions have a percentage of their economically active population in HRST above 37%, i.e. in the top two categories of the classification presented in Map 5. These regions are also among the best performers in terms of % of GDP investment in R&D. All of Ireland and the majority of British regions also fall into these two categories; in the case of the UK, the top-category classification of Berkshire, Buckinghamshire and Oxford (49.9%) and Surrey, East and West Sussex in the top category is also very much linked to the location of world-class universities and the related development of high-tech industries there in the past few decades, including aerospace, military equipment and other electronics, pharmaceutical and medical products, information and telecommunication technologies. East Anglia, where Cambridge and its surrounding Silicon Fen area with its renowned electronics, software and biotechnology cluster are located (While, Jonas and Gibbs, 2004), is part of the second top category with 37.5% of HRST. It is worth noting here that a large part of this NUTS 2 region is rural or semi-rural characterised by an important network of small-scale holiday resorts. Most of Northwest Europe (with the exception of the old industrial regions), and Switzerland, as well as the northern part of Spain, have levels of HRST above 37%.

Overall, Northwest Europe, the Northern Periphery and the northern Baltic Sea region are characterized by relatively high levels of HRST, while, on the other hand, and with the exception of a few regions in the highest categories of HRST (including the capital regions of Slovakia and the Czech Republic in the top ten as mentioned earlier), Southeast Europe, the Mediterranean Basin and Atlantic Axis have, on average, lower proportions of HRST in their economically active population. In particular, a number of Portuguese regions (6) and Greek regions (7) are in the second bottom category of HRST (i.e. between 13% and 24%). These are regional economies still heavily dominated by agricultural production and tourism (Proença and Soukiazis, 2008; http://www.eubusiness.com/europe/greece/). The remainder of the regions that fall into this category are located in Eastern Europe – namely in Bulgaria, Macedonia, Croatia, and Romania (only one region in Romania has a higher share of HRST in their economically active population, it is the capital region of Bucuresti – Ilfov with 43.5%, i.e. more the European median of 36.7% and the European average of 35.8% in 2010) – and in Turkey. As far as Turkey is concerned, the Innovation Union Scoreboard 2011 notes that one of Turkey's main challenges with respect to innovation is the relative weakness in terms of its human resources, which contributes to make it "one of the modest innovators with a below average performance" (Pro-Inno Europe, 2012, p. 58). This is reflected in the fact the bottom ten regions in terms of HRST are all located in Turkey. The rest of the Turkish regions fall into the second bottom category, all with less than 24% of their human resources in science and technology, expect for two regions: Ankara (35.4%, below the European median of 36.7%, but very close to the European average of 35.8%) and Izmir (28.2%). Here again, the main explanation for this lagging pattern in terms of HRST is the fact that, traditionally, Turkey's economy is still dominated by agricultural activities (24.75 of employment) and tourism, two sectors of the economy that employ a majority of low-skilled workers.

3. Research specialisation in NBIC technologies

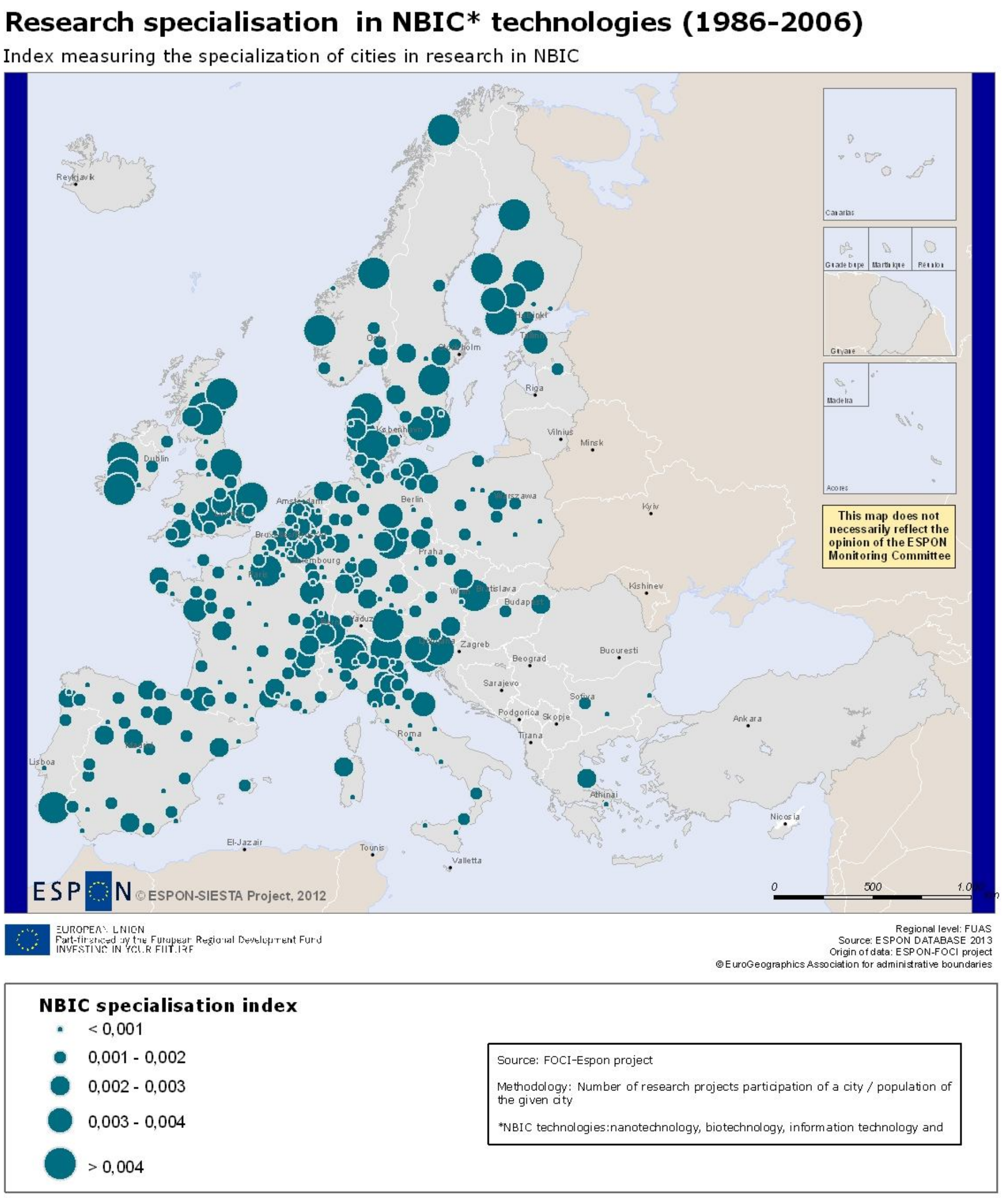
3.1 Meaning of indicator

Map 6 illustrates research specialisation in NBIC technologies across Europe between 1986 and 2006 through the use of an index measuring the specialisation of cities in research in these technologies. Combined nanotechnology, biotechnology, information technology and cognitive science are considered as ‘emerging’ or ‘converging technologies’ and they are expected to drive the next innovation wave (ESPON, 2010b) and this specialisation index is one indicator of how successful particular regions are in attracting public funds for research. The index is a ratio of funded NBIC research projects in a city to the population of the given city (i.e. number of funded NBIC research projects divided by the population of the city in question). The dataset represented on Map 6 was produced by the ESPON-FOCI project (FOCI, 2010b) – a project that analysed, in particular, competitiveness, social cohesion and environmental issues in Europe’s largest urban areas – and is available from the ESPON 2013 Database.

3.2 Relevance

The ‘Innovation Union’ flagship initiative details key targets for building and strengthening Europe’s Smart Growth, as well as some of the key issues that need to be overcome and challenges that need to be tackled. Although “Europe starts from a position of strength” (EU, 2010, p. 6) in terms of R&D, and with respect to innovative technologies in particular, the ‘Innovation Union’ communication emphasises the need for Europe to maintain this competitive advantage over major competitors such as the United States, Japan, but also China and South Korea, which have moved from a position of imitators to a leadership position in terms of innovation. In order to preserve its ‘innovative edge’ and to use it as a key driver of economic growth and job creation (Zagamé, 2010), Europe needs to focus, among other things, on the development of ‘emerging technologies’, including the so-called ‘NBIC’ technologies: nanotechnology, biotechnology, information technology and cognitive science (KIT, 2011*)*. European leadership in the development of international standards for such technologies could potentially improve the competitiveness of European companies and facilitate trade (An Integrated Industrial Policy for the Globalisation Era). Given the strong relationship between research and innovation, key to the development of NBIC technologies is investment in NBIC research projects. Mapping the research specialisation of Europe’s urban areas in NBIC technologies using the index described above provides a picture of the geography of NBIC specialisation, shedding light on poles of excellence that are likely to drive Europe’s NBIC-based growth – in particular through their capacity to attract public funds for research – as well as on areas that have not aimed to or managed to attract funding for NBIC research.

3.3 Specialisation in NBIC technologies in cities



Map 6: Research specialisation in NBIC technologies

Table 5.1 European cities with the highest level of specialisation in NBIC research

Member State	*Urban Area*	*NBIC specialisation index*
Slovakia	Bratislava	0.016404971
United Kingdom	Dundee	0.014880757
United Kingdom	Perth	0.011305396
Germany	Jena	0.011064466
United Kingdom	Aberdeen	0.010588911
United Kingdom	Edinburgh	0.009285520
Switzerland	Neuchâtel	0.008828972
Sweden	Linköping	0.008192905
Denmark	Vejle	0.008144175
Denmark	Aalborg	0.007846255

Table 5.2 European cities with the lowest level of specialisation in NBIC research

Member State	*Urban Area*	*NBIC specialisation index*
United Kingdom	London	0.000220741
United Kingdom	Carlisle	0.000215984
Germany	Rosenheim	0.000170422
Italy	Grosseto	0.000128323
United Kingdom	Inverness	0.000122863
Bulgaria	Plovdiv	0.000116157
Finland	Kotka	0.000100099
France	Maubeuge	0.000083218
Netherlands	Breda	0.000058378
France	Carcassonne	0.000018108

Table 5.3 European cities closest to median level of specialisation in NBIC research

Member State	*Urban Area*	*NBIC specialisation index*
Poland	Poznan	0.001603327
United Kingdom	Leicester	0.001560739
United Kingdom	Swansea	0.001559939
Spain	Orense	0.001558123
Germany	Bielefeld	0.001553803
United Kingdom	Belfast	0.001547448
Austria	Klagenfurt	0.001544956
Italy	Alessandria	0.001522901
Germany	Cottbus	0.001520507
Netherlands	Hilversum	0.001497398

NBIC technologies (nanotechnology, biotechnology, information technology and cognitive science) are converging technologies and have significant potential in terms of not only making scientific progress, but also in terms of translating science into innovation. Therefore, they are highly important elements of the development and consolidation of the knowledge economy in Europe. Map 6 illustrates NBIC specialisation by taking the number of NBIC projects in a city and dividing it by the population of that city. A number of urban areas across Europe have a high index of NBIC specialisation (above 0.004%), putting them at the forefront of the development of these emerging technologies. Map 6 illustrates a broad geographical pattern but there is obvious NBIC specialisation in the Baltic Sea region, Northern Periphery and parts of the Danube Space.

Table 5.1 lists the top ten urban regions in Europe in terms of their NBIC specialisation index. All of these regions have attracted an important amount of funding for NBIC research projects relative to their population size, with NBIC specialisation indexes of close to 0.008 and above (up to 0.016 for Bratislava, Slovakia's capital city). None are major metropolitan areas but rather medium or relatively small cities but because of their intense level of specialisation in NBIC research, we may call them leaders in NBIC research. In line with the overall geographical trend of NBIC specialisation mentioned above, three broad spatial clusters emerge from this top-ten table. First, the most striking geographical feature in this top ten table is the presence of no less than four Scottish cities with very high NBIC specialisation indexes: Dundee (0.015, ranked second right after Bratislava), Perth (0.011, ranked third), Aberdeen (0.010, ranked fifth), and Edinburgh (0.009, ranked sixth). Scotland has strategically been investing in NBIC technologies, in particular in nanoscience, with a view to developing nanotechnology industries across its territory. The dense fabric of renowned universities in Scotland, where collaboration between life sciences, optoelectronics, software and electronics have been encouraged, is likely to act as a key asset in developing NBIC technologies further there, and potentially placing Scotland as a European regional cluster of excellence (Cooke, 2004) and a prominent NBIC leader at the global scale (Snowden, 2007). As we have already seen in Map 5, the role of universities and especially those considered 'world-class' (http://www.timeshighereducation.co.uk/world-university-rankings/2011-2012/europe.html) appears as fundamental in shaping the geography of the knowledge-based/smart growth economy in Europe. The second, and spatially broader, zone of high NBIC specialisation is what we may call a 'central European' corridor where Bratislava in Slovakia (0.016, ranked first), Jena in Germany (0.011, ranked fourth) and Neuchâtel in Switzerland (0.009, ranked seventh) appear as the top players. Finally, a third broader cluster of 'NBIC research champions' emerges from our top-ten table, a Scandinavia cluster this time, with Linköping in Sweden (0.008, ranked eighth), Vejle (0.008, ranked ninth) and Aalborg (0.078, ranked tenth), both in Denmark. This is not surprising given the legacy of high-tech-based growth in Scandinavia countries and their overall high share of human resources in science and technology (HRST) in their economically active population, as displayed on Map 5, and their high proportion of people working in knowledge-based services, as presented on Map 8. Overall, Scandinavian cities – particularly within the Copenhagen – Malmo-Stockholm-Helsinki corridor where % GDP investment in R&D is very high - are well-represented in the top category of NBIC specialisation. In addition to the three urban areas listed in our top-ten table above (Linköping, Vejle, and Aalborg), another 9 Scandinavian cities have a specialisation index of 0.004 or higher – the highest class of specialisation as per Map 6's legend, which encompasses 39 cities. These are: Tromsö (0.007), Trondheim (0.006), and Bergen (0.004) in Norway; Jyvaskyla (0.006), Oulu (0.006), Turku (0.004), and Vaasa (0.004) in Finland; Karlskrona (0.005) in Sweden; and Odense (0.004) in Denmark. All together, these 12 Scandinavian cities make up almost a third of the top category of NBIC specialisation.

Looking at the rest of our data on NBIC specialisation of cities across Europe, and paying particular attention to the ones that have a specialisation index of 0.004 or higher, one can clearly see that Scotland is not the only part of the UK that has been active and successful in attracting funding for NBIC research: another 5 British cities fall into this category of the highest NBIC specialisation index, including cities with world-class universities such as Cambridge (0.006) and Oxford (0.004), in addition to Swindon (0.006), York (0.005) and Norwich (0.004). Given that these convergence technologies are highly synergistic (Roco and Bainbridge, 2002), it is no surprise to see this type of spatial clustering of high performing regions. Ireland also features prominently in this ranking with 3 cities in the top class: Galway (0.006), Limerick (0.005), and Cork (0.004). This is quite remarkable given the relatively small size and population of Ireland in the European context. These cities are located in the western and southern part of the countries, have major universities, and have attracted a number of electronics and pharmaceutical companies in the past couple of decades due in large part to specific government policy. This context would partly explain their higher level of specialisation in NBIC technologies. The Danube Space is also an area of NBIC specialisation, specifically in Germany (Greifswald, 0.004), Austria (Innsbruck, 0.005), Switzerland (Lugano, 0.007; Bern, 0.004), northern Italy (Trieste, 0.006; Trento, 0.006; Varese, 0.004), Slovenia (Ljubljana, 0.005) and, a bit further away from the core of this central European zone, in The Netherlands (Geleen, 0.005; Utrecht, 0.004). Once again, some of these cities are important university centres, reinforcing the overall trend of correlation between European cities' level of specialisation in NBIC technologies and the presence of universities. It may be the case that the NBIC technology is closely linked to technology transfer from universities that are increasingly viewed as important parts of the innovation system (Feldman and Bercovitz, 2006). Finally, also found in the top category of NBIC specialisation are two geographical outliers: Faro (0.005) in Portugal, where one finds the Universidade do Algarve, especially known for its specialisation in marine biology, marine sciences and biochemistry, and Compiègne (0.005), the site of the Université Technologique de Compiègne, a major university pole in France focusing on engineering, including biological, biomedical and computer engineering.

Table 5.2 lists the ten European Cities with the lowest NBIC specialisation indexes (ranging from 0.000018108 for Carcassonne in France to 0.000220741 in London). This indicates that these urban areas have the lowest level of specialisation in NBIC technologies relative to other places in Europe. The question is: is that any indication of a significant 'weakness' in their innovation and smart-growth potential? We would argue that this is not the case. It simply tends to show that these cities might have specialised in other activities, perhaps other knowledge-intensive activities (e.g. London, a global centre for financial services with a high share of human resources in science and technology, as discussed in our analyses of Map 5 and 8 for example), or in more labour-intensive activities (e.g. Plovdiv, Bulgaria's second largest city, a major heavy industries and manufacturing town and food processing centre at the heart of a prosperous agricultural region, and an international transport hub in Eastern Europe). NBIC technologies, like financial services and ICTs (see our discussions of Maps 5 and 8), benefit from agglomeration that allow for increased productivity effects (see Porter, 1990, for example, on the importance of clusters and agglomeration for productivity (Porter, 1990) and the exchange of knowledge and the cross-fertilisation of experiences and expertises, which is crucial for innovation, itself a key component of the development of knowledge-based economies and the Smart Growth agenda of the Europe 2020 Strategy (EU, 2010). This necessarily leads to specialisation in NBIC technologies occurring in certain places and not others; in other words, not every single city in Europe can specialise in NBIC technologies and compete for funding of NBIC research projects. That would lead to a dispersion of R&D funding, which would not be as productive as spatially targeted funding of projects carried on by major players in the NBIC field, some of which belonging to key clusters of NBIC technologies development, such as the ones discussed above.

We will conclude our analysis by highlighting one of its key limitations. Our discussion of Map 6 allows us to shed light on three major geographical clusters – understood in a broad geographical sense – of NBIC specialisation: Scandinavia, the British Isles (the UK – especially Scotland – and Ireland), and a central European corridor roughly spanning from north-eastern Germany, through Switzerland and to northern Italy and Slovenia. It is expected that this is where one would find most of Europe's NBIC leaders and drivers of Europe's global competitiveness in terms of emerging technologies. Our analysis demonstrates that while NBIC specialisation is entirely an urban phenomenon, it is polycentric in form and not solely confined to the largest European capitals and economic centres. It has also demonstrated a capability to contribute to economic competitiveness by simultaneously developing globally integrated economic sectors and strong local economies (Territorial Agenda 2020, para. 33) and is strongest in knowledge networking regions (KIT, 2011b*).* However, in the absence of data on other regions of the world in our dataset, it is impossible to compare European cities with those in other world regions. This is a key limitation in assessing Europe's performance in NBIC research and its potential in terms of innovation and competitiveness in this field compared to the rest of the world, in particular with respect to its major competitors in the knowledge-based economy identified by the Innovation Union communication (EU, 2010), namely the United States, South Korea, China/Hong Kong.

4. Business Expenditure on R&D as % of GDP

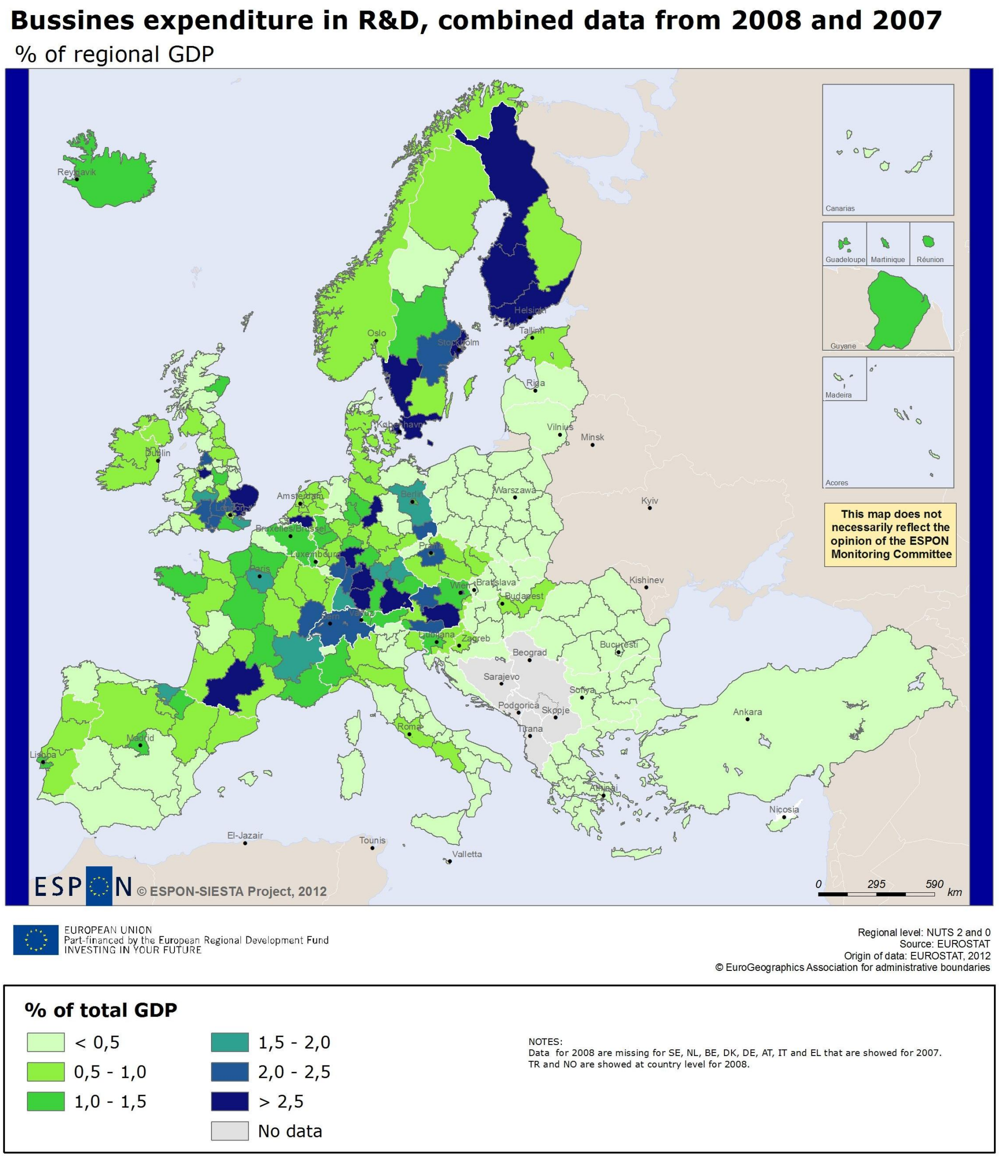
4.1 Meaning of indicator

Investment in R&D is generally analysed by institutional sector: business enterprise (BES), government (GOV), higher education (HES), and private non-profit (PNP) (OECD, 2002). These sectors largely coincide with the kinds of classification used in Systems of National Accounting with the difference that higher education has been established as a separate sector (Robbins, 2006). In Maps 2, 3, and 4 earlier, our analysis focused on overall investment in R&D but Map 7 focuses in particular on private sector or business expenditure on R&D (BERD). In 2007, data availability in BES was 88.1%, in GOV was 92% and in HES was 90% on average. Although this level of data availability marks a significant increase on returns in previous years, EUROSTAT acknowledge that the amount of required statistics for BES is substantially larger than they currently have if one is to assume complete reliability. It is within this context that the following analysis should be read.

4.2 Relevance

R&D intensity measured through R&D expenditure as a % of GDP is one of the headline targets being used to measure the progress of the European Union made towards the Lisbon objectives. The 3% R&D intensity goal is ambitious for most countries, although some Scandinavian countries have set targets in excess of this average, as we noted in relation to Map 2. However within this overall target, the EU2020Strategy established a target of 2% to be achieved for Business Expenditure in R&D (BERD) (Fifth Report on Economic, Social and Territorial Cohesion, p. 45) as private sector investment is considered central to enhancing economic productivity and growth (European Communities, 2006). Rather than direct public expenditure on R&D, the focus of many of the Innovation Union flagship action points is on creating the most favourable conditions for private sector investment. These include measures on access to finance; risk-sharing; the provision of venture capital; cross-border matching of innovative firms with suitable investors; a review of regulatory frameworks and develop a European Knowledge market for patents and licensing (EU, 2010). The data in map 7 provide a baseline from which future trends in BERD can be measured. The growth of investment from this sector will be a key indicator of the success, or otherwise, of the Innovation Union flagship initiative.

4.3 Business Expenditure on R&D



Map 7: Business Expenditure on R&D as % of GDP investment

Table 6.1 Regions with highest levels of BERD as % of GDP (2007/08)

Member State	*Name of region*	*% GDP*
United Kingdom	Cheshire	5.52
Germany	Stuttgart	5.42
Finland	Pohjois-Suomi	4.82
Germany	Braunschweig	4.75
United Kingdom	East Anglia	4.34
Denmark	Hovedstaden	4.03
Sweden	Sydsverige	3.79
Germany	Oberbayern	3.38
Finland	Länsi-Suomi	3.14
France	Midi-Pyrénées	3.13

Table 6.2 Regions with lowest levels of BERD as % of GDP (2007/08)

Member State	*Name of region*	*% GDP*
Greece	Anatoliki Makedonia,Thraki	0.01
Greece	Ipeiros	0.01
Poland	Zachodniopomorskie	0.01
Spain	Ciudad Autónoma de Ceuta	0
Greece	Dytiki Makedonia	0
Greece	Thessalia	0
Greece	Ionia Nisia	0
Greece	Peloponnisos	0
Greece	Voreio Aigaio	0
Greece	Notio Aigaio	0

Table 6.3 Regions closest to median levels of BERD as % of GDP (2007/08)

Member State	*Name of region*	*% GDP*
Hungary	Észak-Alföld	0.61
United Kingdom	Dorset and Somerset	0.61
Germany	Trier	0.6
France	Champagne-Ardenne	0.6
United Kingdom	Northumberland and Tyne and Wear	0.6
Denmark	Sjælland	0.58
United Kingdom	South Western Scotland	0.58
Spain	La Rioja	0.57
Portugal	Alentejo	0.57
Italy	Lazio	0.56

While the EU has made steady progress towards achieving the 3% of GDP investment in R&D outlined in the EU2020 Strategy, the innovation gap between Europe and other major global regions is increasing "notably due to weaker business R&D investment" (European Commission, 2012, p. 3). Given the speed with which other regions are increasing the intensity of these activities, Europe could rapidly become a lagging region in global terms. The European Union is now substantially behind countries such as China, Japan, Korea and the United States in terms of the % of business investment in R&D relative to all investment in this activity. All of these countries display proportions in excess of 70% with the highest level in Japan. 78.2% of all investment in R&D is from industry in this country compared with just 64.17% in the EU15 and 63% in the EU27. In 2008, BERD in Europe was just 2.01% compared with 2.79% in the US and 3.45% in Japan. The average annual rate of growth in business R&D intensity in China from 2000-2008 was 9.2% against 0.3% in Europe (European Commission, 2012, p. 3).

The tables associated with Map 7 illustrate that those areas with the highest business spend on R&D (BERD) almost correlate exactly with those regions that have the highest overall spend on R&D (with the exception of Prov. Brabant Wallon), as illustrated in Map 2. This demonstrates that for the most innovative regions in terms of R&D, business expenditure is a key driver of activity. Areas at the top of the table, such as Cheshire in the United Kingdom and Stuttgart in

Germany (with 94.04% and 92.97% respectively of all investment in R&D from business) have attracted levels of investment 2.5 higher than the EU average. Three of the top 5 regions in terms of BERD are characterised as *forward-looking industrial regions or clusters (*Landesman and Römisch, 2007). In both Stuttgart and Braunschweig (Germany), a specific expertise has been developed in transport technology. Most interestingly, although Stuttgart is known as the 'cradle of the automobile' it is not suffering from the rustbelt status of many cities across the world associated with the car industry such as Detroit in the USA. The city facilitates 'command and control' and R&D functions for many companies such as Daimler AG, Porsche, Bosch, Celesio, Hewlett-Packard and IBM – all of whom have their world or European headquarters here. In addition, educational infrastructure (7 universities and colleges, six Fraunhofer institutes, four institutes of collaborative industrial research at local universities, two Max-Planck institutes and the German Aerospace Centre) plays a significant role in positioning Stuttgart as a core focus of R&D activity in Germany (FOCI, 2010b). Three of the regions in the top ten table, Pohjois-Suomi (Finland), East Anglia (UK) and Midi-Pyrénées (France) - have been characterised in other studies as Agricultural regions or clusters (Landesman and Römisch, 2007). At first this seems counter-intuitive, but on closer inspection it becomes clear that these have very strong but geographically-confined clusters in specific activities. For example, the aerospace and aviation sector accounts for 45% of all private investment in R&D in the Midi-Pyrénées and this is primarily centred on Toulouse which is the headquarters of Airbus, the Galileo positioning system, the SPOT satellite system, and CNES's Toulouse Space Centre (CST), the largest space centre in Europe. A strong ICT and electrical engineering sector has developed around the city of Oulu in Pohjois-Suomi but is geographically constrained within a predominantly rural location (http://www.espon.eu/main/Menu_Projects/Menu_ScientificPlatform/typologycompilation.html?currentPage=3). Similarly, East Anglia scores very highly on general investment in R&D (Map 2) but also on BERD. This is attributable to a technological cluster centred on Cambridge specialising in Electronics, ICT and Biotechnology. Companies such as Toshiba, Nokia and spin-out enterprises from the University of Cambridge account for a large proportion of this investment. However, the Regional Development Agency in the United Kingdom has acknowledged that while the region is good at generating innovations, it is less good at fully reaping the economic benefits of their exploitation and furthermore, that a significant proportion of the activity is focused on a small geographical area around Cambridge. What most of this analysis reinforces is the critical role of universities and technological institutes in driving forward the smart growth agenda, and particularly their role in innovation and regional development (Fritsch and Slavtchev, 2007; Lawton Smith, 2007).

Leaving aside the three key clusters of business investment, in Central Europe, Scandinavia, and parts of southern England, a clear geographic pattern emerges illustrating business investment of 0.5-1.5% investment in NorthWest Europe, the Northern Periphery/northern Baltic Sea and parts of the Atlantic Axis. While these regions still have a significant distance to go to meet a 2% target for BERD by 2020, this is much less than the Eastern Danube Space and Southeast Europe in particular. In the eastern Baltic Sea, Latvia and Lithuania score very poorly and this belt of low performing regions stretches southwards through Poland, Slovakia, parts of Hungary, Bulgaria, Romania, Greece and Turkey. Data for Bosnia-Herzegovina, Macedonia, Albania and Serbia was not available for this analysis. Analysis of the regions for which data was available show that Greece (8 regions), Poland (1 region) and Spain (1 region) have the lowest performances in terms of business expenditure on R&D. Eight of the thirteen regions in Greece show 0-0.01% business investment. All regions are below 0.1% with the exception of Attiki (0.33%) and Dytiki Ellada (0.14%). It is very difficult to fully understand the dynamics of R&D investment in Greece generally due to poor data availability. Of the other regions with low levels of BERD, Zachodniopomorskie (West Pomerania) in Poland also emerges with just 0.01 and is ranked #269 out of 288 NUTS2 regions in terms of general R&D. However, this is considered one of the greenest regions of Poland (two National Parks and seven Landscape Parks) and architectural / cultural tourism plays a major role in the local economy. Explaining the low levels of investment in Ciudad Autónoma de Ceuta is its location in the outermost regions of Europe. Located on the North African coastline, this exclave has special tax status and the economy is heavily dependent on port activity and commerce, especially financial services and tourism. Physical isolation and the relatively limited size and resource base of the region make it an unattractive prospect for R&D particularly in those areas that require synergies with higher education and technological institutes.

The relatively low levels of BERD across Eastern Europe may be a legacy of recent history, and again highlights the path dependent nature of investment decisions. Adjusting to a post-Socialist economic, political and social structure and gaining momentum in terms of private investment may take longer than anticipated in order to form more effective regional innovation systems (Masso and Vahter, 2008; Lengyel and Cadil, 2009). However significant strides are being made to attract private investment into R&D. Although operating from a relatively low base, two regions in Romania display more than 50% BERD (Centru and NordEst) with Nord Est, at 66.67%, exceeding the EU average. Similarly some parts of Bulgaria have shown significant strides in moving from state-based control and influence in enterprise, with Severen tsentralen reporting 44.44% of all investment in R&D coming from the business sector.

In general terms, Europe needs to rapidly increase the proportion of BERD in order to regain competitiveness in a globally competitive economic environment. However, the prospects are bright given that research has shown that companies “that invest in R&D continue to grow while competitors with modest investment suffer sales declines” (Dugal and Morbev, 1992) and a more recent report (Jaruzelski and Dehoff, 2009) highlights that during the recent economic recession the world’s biggest companies increased spending on R&D to ensure their readiness for an economic upturn. This provides an opportunity for Europe to capture a share of this growing pool of investment in R&D activity but a policy decision needs to be made. Should the European Union promote investment into the already successful regions, such as our top 10, that may be better placed to compete globally with other world regions such as the US, Japan or Korea for major investment opportunities or does innovation policy need to play a more effective role in promoting regional development in areas that currently score very low on the R&D investment scale? In a period of crisis, the state may not have the capacity to invest as a way of ‘pump-priming’ the private sector so the focus of policymakers should be on prioritising the transformation of the regulatory and policy context, as a relatively inexpensive way, of increasing Europe’s share of business expenditure in R&D.

5. People working in knowledge-intensive services

5.1 Meaning of indicator

Map 8 presents data on 'People Working in Knowledge-Intensive Services' as a percentage of total employment in the NUTS 2 regions of Europe in 2010. The source of the data is Eurostat. The Eurostat definition of knowledge-intensive services encompasses the following sectors, defined by NACE[1] code:

- Knowledge-intensive high-tech services, including: post and telecommunications; computer and related activities; and research and development;
- Knowledge-intensive market services, excluding financial intermediation and high-tech services, including: water transport; air transport; real estate activities; renting of machinery and equipment without operator, and of personal and household goods; and other business activities;
- Knowledge-intensive financial services, including: financial intermediation, except insurance and pension funding; insurance and pension funding, except compulsory social security; and activities auxiliary to financial intermediation;
- And other knowledge-intensive services, including: education and health and social work.

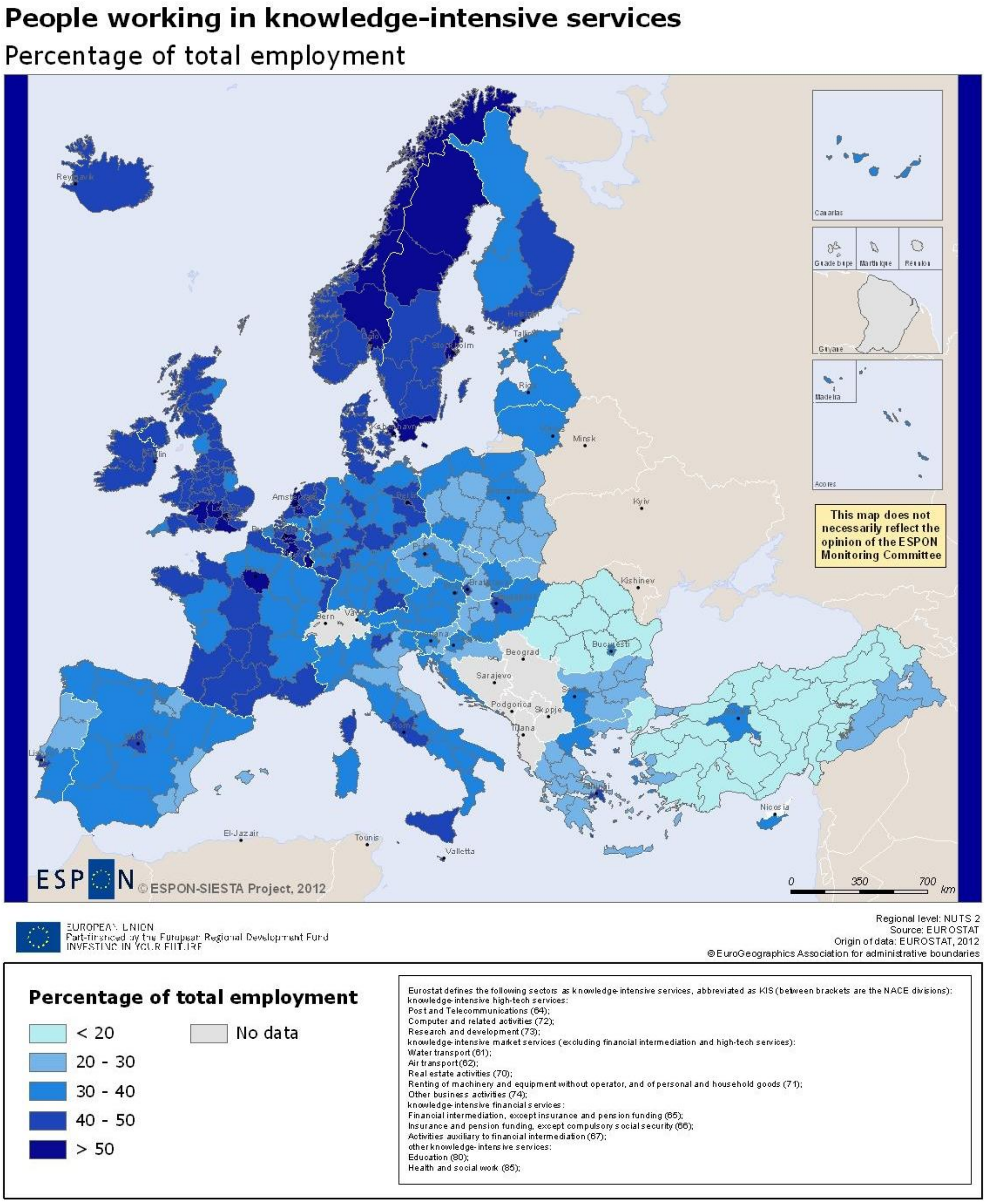
5.2 Relevance

The 'Innovation Union' flagship initiative (EU, 2010) is one of three key programmes that details Europe's targets, priorities, and challenges in terms of consolidating and developing further Europe's smart growth as outlined by Europe 2020 Strategy's Smart Growth. Smart growth is based on the development and expansion of knowledge-intensive activities in which the human component remain fundamental, in particular because innovation is still driven to a great extent by human 'brain power', expertise, and cross-fertilisation of knowledge. This means that the proportion of people working in knowledge-intensive activities, including knowledge-intensive *services*, across European regions, as represented on Map

[1] Statistical classification of economic activities in the European Community.

8, is a key indicator of how well–positioned European regions are in terms of contributing to Europe's position on the global map of the knowledge-based economy.

5.3 Employment in knowledge-intensive services



Map 8: People Working in Knowledge-intensive services

Table 7.1 Regions with highest % of people working in knowledge-intensive services

Member State	*Region*	*%*
United Kingdom	Inner London	66.04
Spain	Ciudad Autonoma de Ceuta	61.18
Norway	Oslo og Akershus	59.73
Sweden	Stockholm	59.47
Denmark	Hovedstaden	58.93
Luxembourg	Luxembourg	54.98
Norway	Nord-Norge	54.26
United Kingdom	Outer London	53.08
United Kingdom	Berkshire, Buckinghamshire, Oxfordshire	53.00
Finland	Åland	52.69

Table 7.2 Regions with lowest % of people working in knowledge-intensive services

Member State	*Region*	*%*
Turkey	Agri	14.75
Romania	Sud-Vest Oltenia	14.74
Turkey	Gaziantep	14.66
Turkey	Bursa	14.26
Turkey	Balikesir	14.02
Turkey	Hatay	13.51
Turkey	Tekirdag	13.15
Turkey	Zonguldak	12.83
Turkey	Manisa	12.83
Turkey	Trabzon	12.23

Table 7.3 Regions closest to median % of people working in knowledge-intensive services

Member State	*Region*	*%*
Germany	Stuttgart	38.16
Austria	Niederösterreich	38.09
France	Poitou-Charentes	38.02
Finland	Pohjois-Suomi	37.98
France	Picardie	37.95
France	Haute-Normandie	37.82
Germany	Münster	37.68
France	Franche-Comté	37.60
Germany	Freiburg	37.35
Germany	Braunschweig	37.13

In addition to high levels of expenditure in research and development, an adequate level of people working in knowledge-intensive activities, including services, is a key pre-requisite to the continued development of a strong knowledge-based economy in Europe. The Fifth Report on Economic, Social and Territorial Cohesion (p. xii) highlights the importance of maintaining Europe's competitive edge globally as reflected in the balance of trade in services through consolidating and strengthening knowledge-intensive activity. While on average the proportion of people working in knowledge-intensive services compared to other sectors of the economy seems relatively high (36.60% in 2010), the 'Innovation Union' communication points out that "although our services sector accounts for 70% of the economy, our knowledge intensive services are still under-developed" (EU, 2010, p.7). At first sight, this can appear as a surprising statement, in particular if one thinks of well-established world-class clusters of advanced-producer services (APS) providers such as London or Paris (see, for example, Moulaert, 1995). However, part of the concern with the development deficit that the Innovation Union communication highlights as a major challenge to Europe's smart growth objectives might stem from very important disparities between European regions in terms of knowledge-intensive activities, both in terms of manufacturing and services. As far as services are concerned, the European geography of knowledge-intensive services is quite uneven, as Map 8 illustrates.

Table 8.1 highlights the top-ten European regions in terms of employment in knowledge-intensive services. Without much surprise, and in line with the ranking of regions in terms of the share of human resources in science and technology – see Map 5 - in their economically active population, Inner London ranks first, with 66.04% of its employed active population working in knowledge-intensive services. Inner London comprises London's 13 so-called inner boroughs and the City of London, which has a specific administrative status. A very large portion of these 66.04% of workers in knowledge-intensive activities in Inner London would be employed by the banks and the large multinational financial institutions located in the Square Mile – the City's nickname – and in Canary Wharf in the eastern inner borough of Tower Hamlets; Canary Wharf is London's 'other' financial centre, developed in the former docklands area in the 1980s (Church, 1988) to alleviate the growing real-estate pressure in the City that went along with the elimination of capital controls and the liberalisation of financial markets in the United Kingdom (UK) in 1986 (Bayoumi, 1993; Gaffikin and Warf, 1993). It is important to note that it is not only the banks and financial firms that are responsible for the very high share of knowledge-intensive service employment in inner London, but a host of companies that service the financial economy, including consultants, accountants, audit firms, insurance and re-insurance companies, legal services, market data analysts, IT services etc, all of them sustaining the so-called 'global city' economy (Sassen, 2001). The Outer London NUTS2 region also appears in the European top ten in terms of employment in knowledge-intensive services (53.08%). Once again, this is very much linked to the hyper growth of financial and related services in the UK since the 1980s and corresponds to the relocation of many back-office functions to less central and therefore less expensive areas of the city in terms of real-estate. The clustering of financial services activities is also what explains the high ranking of Luxembourg in terms of the share of knowledge-intensive services jobs as a percentage of total employment (54.98%). One region that appears as quite a 'geographical outlier' in our table is the Autonomous City of Ceuta, a NUTS 2 region of Spain located in North Africa, ranking number two in Europe with 61.18% of its working population people employed in knowledge-intensive services. The position of Ceuta in this table is primarily due to the relaxed business and tax environment that has attracted many financial and related institutions. The small free port territory has become to a great extent a tax haven but because of its small size in geographical and population terms, it is not particularly economically significant.

The above ‘top ten’ table also lists five Scandinavian NUTS 2 regions as regions with a very high share of workers in knowledge-intensive services: Oslo og Akershus (59.73%), the capital region, and Nord-Norge (54.26%) in Norway, Stockholm (59.47%) in Sweden, Hovedstaden (58.93%) the capital region around Copenhagen (58.93%) in Denmark, and Åland (52.69%) in Finland. The main driver here is the information and communication technology (ICT) sector that has been a key engine of growth in many parts of Scandinavia in the past few decades, including the early breakthrough successes of companies such as Nokia in Finland in the field of mobile technologies or Skype in Sweden in the field of Internet technologies. Employment in ICT would be partly industrial, but also, to a large extent, service-based, including a lot of research and development activities, but also design, marketing and legal activities. As far as Norway is concerned, the oil industry would also be an important employer of knowledge-intensive services. In the case of Åland in Finland, this very small autonomous Swedish-speaking archipelago at the southern tip of Finland (where only 0.5% of the Finnish population lives) listed as number ten in our table above owes its high ranking to its shipping activities (Andersson, and Eklund, 1999; EUROISLANDS, 2010) and to the presence of a few high-profile technology companies there.

It is worth noting that the UK has another region listed in the top ten regions with the highest share of people working in knowledge-intensive services, which is the Berkshire, Buckinghamshire, Oxfordshire NUTS2 region (53.00%). Among the reasons for this high ranking are the presence of many finance-related back-office functions (as in the case of Outer London), a large number of business services, and advanced producer services in particular, which support the flourishing high-tech industries in the region (e.g. pharmaceuticals and health industries, military equipment, aerospace, information and telecommunication technologies, electronics), and the location of a number of a major universities and their spin-outs in the region (which would also be a factor in explaining the high share of knowledge-intensive service employment in both Inner and Outer London), including Oxford and the Open University in Milton Keynes, which specialises in high-quality distance learning. Overall, financial and related services, advanced producer services and the presence of a number of or large universities appear to be key variables in explaining over 50% of workers employed in knowledge-intensive services in 24 NUTS 2 regions of Europe, located mainly in the Northwest of the territory. Specifically these regions are in the UK (South and Southeastern regions, making up the British ‘sunbelt’), in Scandinavia (the whole eastern half of Norway; the northern half of Sweden, its southern tip and its capital region of Stockholm; the Åland region in Finland;

and Denmark's capital region of Hovedstaden around Copenhagen), in Belgium (in the broader region around Brussels, including the Flemish and Walloon parts of the Brabant region and around Namur), in The Netherlands (in the northeastern part of the country, in the North Holland region that comprises the greater Amsterdan region, and the Utrecht region), and the capital regions of Germany (Berlin) and France (in the Île de France region that includes Paris). It would be expected that these regions would do relatively well on this indicator as knowledge-intensive activities favour those that are most highly educated; however this does not necessarily guarantee high levels of labour force participation which is another key goal of the EU2020 Strategy given that knowledge-based growth models can be highly exclusionary for the low qualified populations (FOCI, 2010).

At the other end of our ranking of regions in terms of the percentage of their total employment in knowledge-intensive services are ten regions that are all but one (the southern Romanian region of Sud-Vest Oltenia, by the Serbian and Bulgarian boarders) located in Turkey, with percentages between 12.23% and 14.75%. This is very much in line with the spatial pattern of human resources in science and technology displayed and discussed in our analysis of Map 5. Most Turkish NUTS 2 regions are indeed under the 20% mark in terms of employment in knowledge-intensive services, except for major urban areas such as Istanbul, Ankara, Izmir and Bodrum. There is thus a significant and possibly growing urban-rural divide in Turkey. This 'lagging' pattern in terms of knowledge-intensive services is to be attributed to a great extent to the legacy of an economy largely based on agricultural production (as opposed to industrial production, which has often triggered the development of industry-related knowledge-intensives services in former peripheral European economies, as in the case of electronic components in the 1970s and 1980s in Ireland for example (CAEE, 2010) as well as a service economy dominated by tourism, which is much more labour-intensive than knowledge-intensive. This major discrepancy between Turkey and most of the rest of Europe in terms of growth based on knowledge-intensive activities, including services – the average share of employment in knowledge-intensive services across Europe minus Switzerland and Macedonia for which we do not have data, was 36.60% in 2010) – is an issue to be considered when thinking of the potential future membership of Turkey into the European Union (EU) and what that means in terms of economic policy and targets, in particular in terms of smart growth. It is important to highlight, however, that many of the other regions that are under 20% of employment in knowledge-intensive are in Romania (all of Romania actually, except for the capital region of Bucureşti-Ilov around Bucharest with 39.08%, i.e. above the European average), and this did not prevent Romania from joining the EU in 2007.

Several interesting spatial patterns and issues emerge from Map 8 and our analysis:

- The overall gross geographical pattern of employment in knowledge-intensive services is characterized by a gap between Scandinavia, the British Isles and Western Continental Europe on the one hand, where employment in knowledge-intensive services usually represents an important share of total employment, and Eastern and Southern Europe on the other hand, where knowledge-intensive services are far from being the largest employers. Among these 'lagging regions' in terms of employment in knowledge-intensive services, Turkey is particularly 'behind'. The potential impact of this discrepancy on Europe's overall smart growth objectives, if Turkey was to join the European Union in the near future, needs to be addressed.
- Major financial centres such as London and Luxembourg are among the most intensive employers of in knowledge-intensive services, and they are clearly major assets in terms of developing Europe's knowledge-based economy. These banking and financial hubs, where constant product innovation is key to success, are some of the command and control centres of contemporary capitalism characterized by an increasing level of globalization and financialization. Their capacity to innovate is what put them at the very top of the global urban hierarchy in terms of the spatial division of labour (Massey, 1984) as per the world city (see for example Beaverstock, Smith and Taylor, 1999) and global city literatures (see for example Sassen, 2001). They represent key assets to maintain Europe's status as a prominent player in the global economy.
- Another stronghold of employment in knowledge-intensive services is Scandinavia. This highlights the driving force of information and telecommunication technologies (ICTs) in Europe's smart growth and this region has been identified elsewhere as a core of product innovative activity in Europe (KIT, 2012, p. 2).
- Both of the above driving sectors of Europe's knowledge-based service economy – financial and related services, and ICTs – are characterised by high-level of agglomeration owing

to the importance of spatial proximity for the exchange of personnel, ideas and expertise that is necessary to the cross-fertilisation of knowledge that is key in triggering innovation (CAEE, 2010). This is a potential strength that needs to be further developed given that “formal knowledge, in the form of R&D and patents, generates innovation only in those areas that register a critical mass of this kind of knowledge” (KIT, 2012, p. 43).

6. Patent applications in 2008

6.1 Meaning

One of the key indicators used to assess levels of research and innovation is patent applications. Drawing on statistics from the European Patent Office (EPO), Maps 9 and 10 present data on patent applications and high-tech patent applications in 2008. **Map 9** illustrates a ratio of patent applications, expressed as number of applications per 1,000 inhabitants. Data are presented at the regional level, mostly at NUTS 3 level, except for Belgium, The Netherlands and Iceland, for which data are displayed at NUTS 2 level. **Map 10** demonstrates the proportion of high-technology patent applications as a percentage of total patent applications to the EPO in 2008 at NUTS 2 level. The definition of high-technology (high-tech) patents is based on specific subclasses of the International Patent Classification (IPC) as defined by the trilateral statistical report of the EPO, JPO (Japan Patent Office) and USPTO (United State Patents and Trademark Office). The sectors defined as high-tech are: aviation, computer and automated business equipment, communication technologies, laser technologies, semiconductors, micro-organisms and genetic engineering. The data used to produce Map 9 come from the OECD (Organisation for Economic Cooperation and Development) REGPAT database, while data used for Map 10 (and 'Map 10 context') were extracted from Eurostat. In both cases, the original source of the data on patents is the EPO where applications are recorded according to the year in which they are filed, the inventor's place of residence, and the IPC category which they belong to, using fractional counting if multiple inventors or multiple IPC categories are provided, in order to avoid double counting.

6.2 Relevance

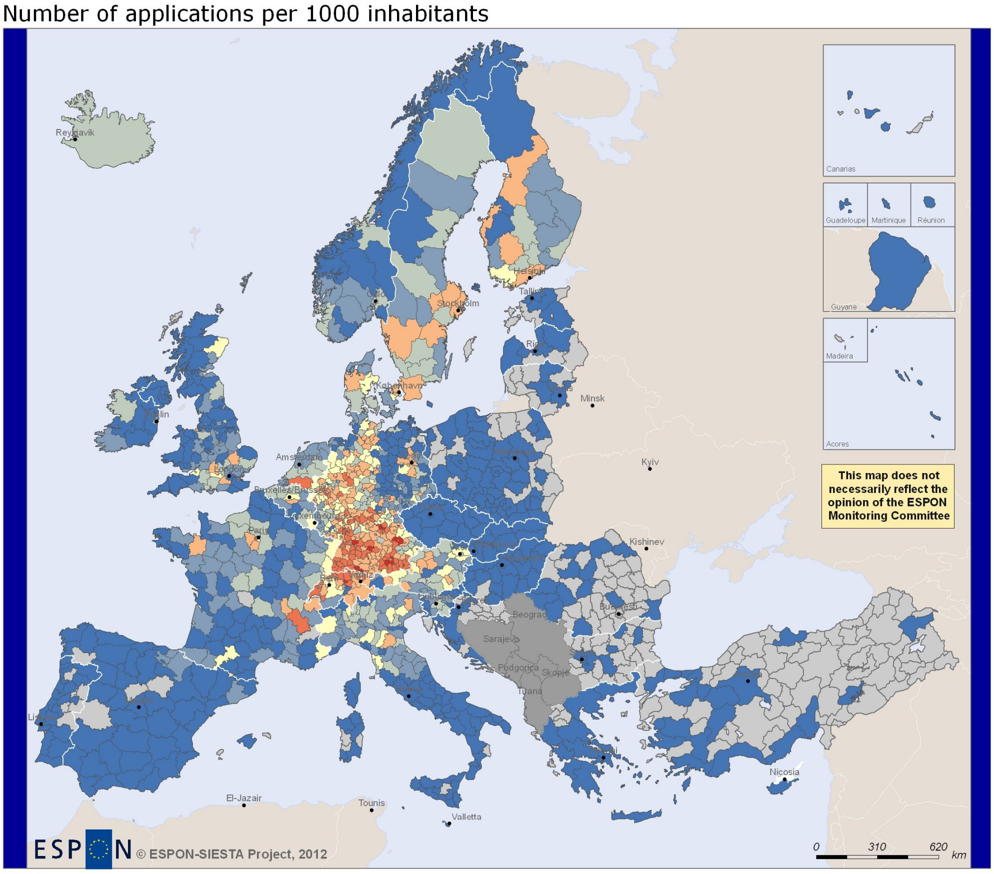
Patent and patent statistics are commonly used by economists to identify sources of economic growth, to assess rates of technological change, and to understand differentials in levels of competitiveness (Griliches, 1998). Crucially, patent statistics are used as tools or proxies to measure levels of innovation, to see how they compare across space and to understand differentials in levels of 'inventiveness' and abilities to transform R&D into innovation. These differentials are fundamental drivers of competitiveness, insofar as they are a key factor in creating competitive advantages.

The Innovation Union flagship initiative (EU, 2010) highlights the urgent need to reform the patent system in Europe, which is costly and fragmented, to create a single innovation market. As explained in the Communication, “a critical issue for innovation investments in Europe is the cost and complexity of patenting. Obtaining a patent protection for all 27 EU Member States is currently at least 15 times more expensive than patent protection in the US19, largely due to translation and legal fees. The absence of a cheap and simple EU patent is a tax on innovation. The EU Patent has become a symbol for Europe’s failure on innovation. It would save innovative businesses an estimated €250 million and must be adopted without delay, to show that the EU is serious about becoming an Innovation Union” (EU, 2010, p.15). The initiative recommends the development of a cheap, simple, single EU patent system by 2014 as a first key step to remove “remaining barriers for entrepreneurs to bring “ideas to market” (EU, 2010, p.3) and thus facilitate the commercialisation of R&D.

6.3 Total patent applications to the EPO in 2008

Patent application to the EPO by inventor´s region of residence, 2008

Number of applications per 1000 inhabitants



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Regional level: NUTS 2 and 3
Source: EUROSTAT and OECD Regpat database
Origin of data: EUROSTAT and OECD Regpat database
© EuroGeographics Association for administrative boundaries

Number of patent applications to the EPO per 1000 inhabitants

- < 0,05
- 0,06 - 0,10
- 0,11 - 0,15
- 0,16 - 0,20
- 0,21 - 0,40
- 0,41 - 0,80
- > 0,80
- 0 patent aplications in 2008
- NO DATA

NOTES:

NL and EL are shown at NUTS 2 level. IS is shown at country level.

Map 9: Patent applications by inventor’s region of residence

Table 9.1 Regions with the highest numbers of patent applications to the EPO per 1000 inhabitants in 2008:

State	*Region*	*Number*
Germany	Erlangen, Kreisfreie Stadt	1.89
Germany	Heidenheim	1.40
Germany	Erlangen-Höchstadt	1.31
Germany	Ludwigsburg	1.04
Germany	Starnberg	0.95
Germany	München, Landkreis	0.87
Germany	Regensburg, Landkreis	0.85
Switzerland	Zug	0.83
Germany	Bodenseekreis	0.82
Germany	Mainz-Bingen	0.80

While the Innovation Union Communication states that "the United States and Japan continue to lead the EU in innovation performance" (EU, 2010, p.8), according to OECD statistics (http://stats.oecd.org/) the 27 member-states are performing well on at least one innovation indicator, namely patent applications. In 2008, the EU27 had filed a total of 359,558.15 patents under the Patent Cooperation Treaty (PTC), compared to 357,447.20 for the United States, 227,845.18 for Japan, 60,464.65 for South Korea, 55,488.01 for China, and 8,241.76 for India. However, as we will see in our discussion of Map 9, a majority of patent applications emerged from one particular part of Europe, the European geography of patent applications being very uneven and characterised by a very high concentration of high-performers within a fairly defined part of Central Europe that is endowed with high-quality human capital (KIT, 2010, p. 17).

German regions have the highest numbers of patent applications per 1,000 inhabitants than any other regions (for which we have data) in Europe. Table 9.1 is dominated by German regions (9 out of 10, the other being located in Switzerland), which are the highest performers in terms of patent applications, all with a ratio of 0.8 ‰ or higher. These top achievers are all concentrated in the southern half of Germany – some of them bordering each other (e.g. Starnberg and München, Landkreis; Erlangen, Kreisfreie Stadt and Erlangen-Höchstadt) – where the other regions also have relatively high numbers of patent applications to the EPO per 1,000 inhabitants, i.e. 0.21% and above. The wider area around this highest- performing cluster, including the whole of Germany and the northern part of Switzerland, also experiences higher ratios of patent applications than in the rest of Europe, resulting in a very distinct and polarized European geography of patent applications. Our ranking of regions reveals that 19 of the 20 highest performing regions are German, as are 28 of the top 30 regions. In the 100 top performing regions (out of 1352 for which we have data), only 11 were not German: 10 were Swiss regions, one was located in Austria.

A key explanatory factor for the overwhelming lead of Germany in terms of patent applications has to do with the status of Germany as Europe's industrial leader through its many large industrial groups such as Bosch, Siemens, or Daimler Chrysler to name a few, which tend to file for several hundred or even several thousand patents every year. Patents are especially important in the manufacturing and science-and-technology-based sectors of the economy. By contrast, service sectors (e.g. tourism, finance etc.) have little or no patents at all. Therefore, a country that has a substantial high-tech manufacturing sector would be expected to have a higher patent count than one that does not. This is certainly the case with Germany. Moreover, the propensity to patent varies significantly across industrial sectors. For instance, patenting in telecommunication technologies and in chemicals and pharmaceuticals is by a factor of 1,000 higher than in textiles, paper manufacturing, or similar activities (Chabchoub and Niosi, 2005). Accordingly, a country like Germany that is heavily involved in the former sectors – telecommunications and chemicals – would be expected to have a higher patent count. Finally, given the importance of patenting for the numerous industrial firms operating from Germany, it is highly possible that a strong German expertise in patenting has developed over time, which provides Germany with an edge over other countries, and could help other European member-states if shared. We could imagine that this is the kind of 'knowledge sharing' – "which is increasingly how successful innovations are developed" (EU, 2010, p.7) – that the Innovation Union Communication advocates.

The region of Zug is the only non-German region in our table and is one of the smallest cantons in Switzerland. Zug is a German-speaking canton located in central Switzerland, not too far from Germany's southern border. Despite its modest size and the fact that most of the canton's land is used for cattle grazing, Zug is home to a very important number of companies (over 24,300 in total), especially corporate headquarters attracted by the fact that Zug has among the lowest levels of taxes in Switzerland. This would explain Zug's performance in our patent applications ranking, given that headquarters' postal addresses are mostly used when applying for patents. This case highlights the need to consider the role of regulation, in particular differences in national and/or regional tax legislations – including the existence of tax havens – in understanding the geographical distribution of patent applications, and its possible disconnect with other indicators relating to 'inventiveness', R&D, and, more generally, the knowledge economy.

In contrast with the discussion on other indicators, there is no 'bottom-ten' table included for Map 9 as, out of 1352 regions for which we have data, 187 regions had no record of filing a patent application with the EPO in 2008. 65 of these regions were located in Turkey, followed by Romania (28), Bulgaria (22), Croatia (14), Poland (14), Spain (12), Lithuania (9), Portugal (7), and a few regions (less than 5) in Austria, Germany, Estonia, France, Greece, Hungary, Italy, Latvia, Montenegro and Sweden. Generally, most of the regions that did not file a single patent application with the EPO in 2008 were located in South East Europe, in the eastern half of the Danube Space, in the eastern part of the Baltic Sea Region and in the Iberian Peninsula. This pattern is more or less consistent with spatial patterns highlighted by our discussions of other Research and Innovation indicators (Maps 2 to 8) and of some Education indicators (Maps 11 to 20), and may be explained by a series of structural factors (e.g. predominance of agricultural activities, traditional manufacturing and/or tourism, which are not the sectors of the economy which are the most prone to patenting, as opposed to high-tech industries and, to a lesser extent, some advanced producer services) and path-dependent considerations.

In summary:

- While the European Union, through, in particular, its industrial leader Germany, is performing relatively well in terms of patent applications compared to major competitors, it is not performing well in harvesting and maximising the benefits of patents through substantial revenues. This is highlighted by the Innovation Union Communication (EU, 2010), which shows a performance gap of -222 in terms of licence and patent revenues between the EU and the US in 2008. Europe's issue in terms of patents seems to be mainly a problem of converting patents into products and revenues, or one of commercialisation. Many of the 34 action points developed as part of the flagship initiative try to address this key issue.
- Another concern is the very uneven geography of patent applications in Europe, which differentiates it from the United

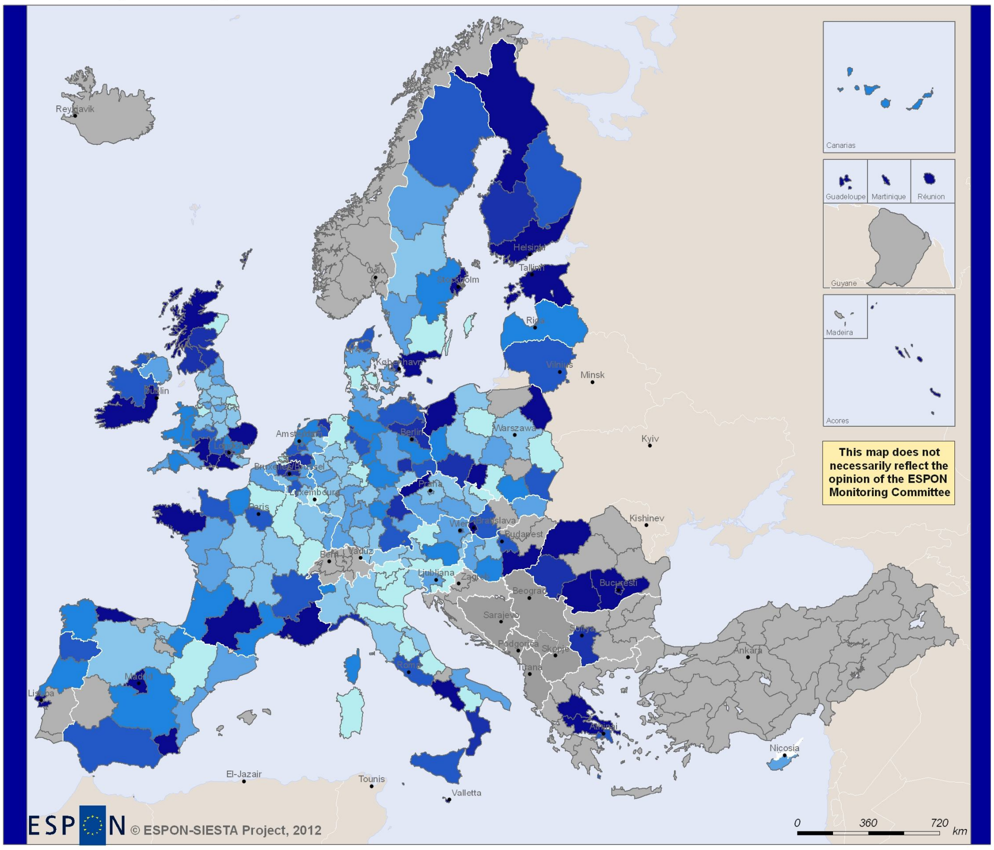
States but is similar to the pattern found in China and India. The KIT report (2011, p.8) similarly notes “the USA has a smoother spatial distribution of patents by applicant than either China or India. In China patenting activity is concentrated along coastal regions, especially in the South. The overall system is highly agglomerated, with the top 3 regions accounting for 73%. In India, patent counts are highest in high-tech clusters such as Bangalore, Chennai, Delhi, Hyderabad, Mumbai and Pune”. Perhaps there are policy lessons that could be transferred from the United States to encourage a more even or distributive geography of innovation commercialisation in Europe.

- Given the uneven nature of patent applications and R&D investment, it would be a mistake for the EU to rely solely on this kind of formal knowledge to develop its innovative capacity. Rather, the potential for local, informal and more tacit knowledge to drive innovation in less technologically advanced regions (KIT, 2011b) needs to be explored and supported if the European territory as a whole is to be become a global hub of innovation. This is closely linked to our previous recommendation (Maps 2-4) that the definition of innovation being utilised and promoted by the European Union needs to be significantly broadened to take account of bottom-up and process innovation as well as top-down initiatives.

6.4 High-tech patent applications to the EPO in 2008

High tech patent applications to the EPO, 2008

% of total patent applications



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Regional level: NUTS 2
Source: EUROSTAT
Origin of data: EUROSTAT, 2011
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% of total patent applications

- 0,96 - 5,00
- 5,01 - 10,00
- 10,01 - 15,00
- 15,01 - 20,00
- 20,01 - 25,00
- 25,01 - 30,00
- 30,01 - 100,00
- No data

Data refer to applications filed directly under the European Patent Convention or to applications filed under the Patent Co-operation Treaty and designated to the EPO (Euro-PCT). Patent applications are counted according to the year in which they were filed at the EPO and are broken down according to the International Patent Classification (IPC). They are also broken down according to the inventor's place of residence, using fractional counting if multiple inventors or IPC classes are provided to avoid double counting.

This map shows the ratio of high technology patent applications to total patent application. The definition of high-technology patents uses specific subclasses of the International Patent Classification (IPC) as defined in the trilateral statistical report of the EPO, JPO and USPTO. The sectors included as high-tech are the following ones: Aviation, Computer and automated bussiness equipment, Comunication technology, Laser, Semiconductors, Micro-organism and genetic engeneering.

Map 10: High-tech patent applications to the EPO in 2008

Table 9.1 Regions with highest proportions of high-tech patent applications as a % of total patent applications in 2008

Member State	*Region*	*%*
Greece	Sterea Ellada	100.00
France	Guadeloupe	100.00
France	Martinique	100.00
Portugal	Região Autónoma dos Açores	100.00
Romania	Sud-Muntenia	100.00
Romania	Sud-Vest Oltenia	100.00
France	Réunion	60.06
France	Bretagne	58.91
Romania	Bucureşti-Ilfov	56.78
Czech Republic	Severozápad	48.51

While Map 9 provides us with a rather clear picture of German regions as the highest performing regions in terms of patent applications – and therefore they can be considered as highly innovative by that standard – Map 10 and its accompanying table are less clear-cut. While German regions do not feature at all among the top-ranking regions in terms of proportion of high-tech patent applications to the EPO, several regions classified as 'outermost' regions such as the peripheral, overseas French territories of Guadeloupe (100% of high-tech patent applications), Martinique (100% also), and La Réunion (60.06%), alongside the Portuguese archipelago of the Açores (100%) – all of which have regional economies relying heavily on tourism and agricultural production of 'exotic produce' – appear as top performers. Completing the top ten, with rates of between 48.51% and 100%, are the following: the central Greek region of Sterea Ellada, home to several ancient cities such as Thebes, which attracts thousands of tourists every year; the Romanian provinces of Sud-Muntenia (a region that has a strong industrial base including automotive production, chemicals and textiles), Sud-Vest Oltenia (a rural region dominated by agriculture but with some manufacturing, for example automobile plants, heavy electrical and transport equipment), and the capital region of Bucureşti-Ilfov; the French region of Bretagne, which has developed its automotive and its ICT sectors in the past few decades but also remains one of France's main agricultural regions; and the Czech region of Severozápad, a well-known spa resort.

Despite the presence of important high-tech poles in some of these regions (e.g. in Bretagne in France), none of these regions would be considered as a core driver of Europe's high-tech industries. So why might Map 10 and Table 9.1 give the impression that they are prominent centres of high-tech innovation? The map and related table present important limitations as they can actually only give a (very limited) sense of certain region's specialisation in high-tech as far as their patent applications are concerned, but cannot provide an accurate reflection of performance in terms of the production of high-tech patents. For example, six of these regions had only one or less than one patent application (fractional counting is explained in the 'Meaning' section above) in 2008, which happened to be classified or partly classified as high-tech in terms of IPC categories. Hence the 100% rates that appear in the ranking table. It is impossible to talk about performance based on that, and it would be extremely difficult to even talk about specialisation. Out of the 10 regions listed in the table above, only Bretagne, in France, would be considered as a serious performer with 187.85 high-tech patent applications out of a total of 318.89 patent applications in 2008 (i.e. 58.91% of high-tech applications). In order to identify the actual top performing regions in terms of high-tech patent applications, we would need to map the numbers of high-tech patent applications to the EPO per 1,000 inhabitants in a similar process to Map 9. A similar issue arises in relation to ICT patents (Map 22) and Green technology patents (Map 33). In both of these maps, there is no obvious pattern of patenting but it is interesting to note that in the part of Europe with the greatest level of overall patenting (Western Danube space, in particular southern Germany, Switzerland and parts of Austria), the proportions of ICT and green patenting are very low. The highest proportions of green technology patents are in relatively peripheral locations in Eastern Europe, Turkey, the Atlantic Axis and Northern Periphery, and a similar pattern emerges with green patents. This suggests that these parts of Europe may be developing specialisation in these activities as a way of achieving smart growth but it has yet to achieve a critical mass.

There is no 'bottom-ten' table included in our discussion, as the list of regions with 0% of high-tech patent applications for 2008 is long. Out of 274 NUTS2 regions for which we have data (we have data for all EU27 countries, but no data is shown on Map 10 for non-EU countries such as Iceland, Turkey, Switzerland, or Norway), 34 had no high-tech patent applications in 2008.

7. Smart Growth: Research and Innovation Overview

7.1 Regions or Cities suffering weaknesses

The picture of research and innovation in Europe is a complex one with clear evidence of national as well as pan-European disparities. Relatively few regions have already exceeded or are close to reaching EU2020S targets, and those that have tend to be in North West Europe and the Northern Periphery. In general South East Europe and parts of the eastern Danube Space are performing poorly on the indicators examined. Investment in Research and Development (R&D) as a % of GDP in these regions is low and this is mirrored in the data for Business Expenditure on R&D (BERD). Almost all regions in Greece emerge at the bottom of the league table in relation to BERD although regions elsewhere score more poorly on general R&D investment. This pattern may indicate an historic over-reliance on public finances to drive the R&D agenda in Greece. Similarly, the particularly low levels of investment in South East Europe and the eastern Danube Space may be heavily influenced by recent history. Many of these countries until recent decades were governed by Communist regimes and the transitional nature of their economies may explain their 'lagging' nature relative to general European averages. Some outliers do exist in parts of Romania and Bulgaria but investment appears highly localised with little spin-off to neighbouring regions.

The current pattern of R&D investment in Europe is thus heavily path-dependent and this has been recognised in the identification of lower national targets for R&D investment in lagging regions, well below the European average of 3%. However, the result is that some regions that appear to have the furthest distance to go to reach national R&D investment targets are not in this geographical space, but in the northern Baltic Sea region, particularly parts of Scandinavia. This reflects more ambitious R&D targets identified by some governments (for example, Sweden have a 4% target). However, it is also influenced by the physical environment as in the case of remote Northern Sweden, for example, within the Arctic Circle, where it is obviously more difficult to attract investment. The outermost regions of Europe – Acores, Madeira, Canarias and Ciudad Autónoma de Ceuta – also demonstrate significant weaknesses in R&D investment generally but this is to be expected given their geographical location and profile.

The general patterns of weakness in relation to R&D investment are also reflected when particular economic sectors are examined. South East Europe, the eastern Danube Space and Turkey have low levels of people working in knowledge-intensive services, poor levels of Human Resources in Science and Technology (HRST), and lower ratios of patent applications to the EPO per 1,000 inhabitants. NBIC technologies (Nanotechnology, Biotechnology, Information technology and Cognitive science) are not a major development focus in these regions. Bulgaria, Macedonia, Croatia, Romania (with the exception of Bucharest) and Turkey (with the exception of Ankara and Izmir) score very poorly across these indicators. The Innovation Union Scoreboard 2011 (Pro-Inno Europe, 2012, p. 9) has acknowledged and highlighted this as a major challenge to be overcome on the path to economic growth and development. There is clearly a strong, although not a causal, relationship between urbanisation and R&D investment, especially in terms of BERD. Countries that tend to be more rural will find it difficult to source the skilled labour pool required to promote R&D. Given the importance of path dependency, the combination of low levels of urbanisation, a history of communist or autocratic regimes in this broad region, and a traditional emphasis on labour-intensive activities such as agriculture and tourism, will make it very difficult for South East Europe in particular to meet EU targets on R&D investment.

Another key challenge will be maintaining momentum in what might be considered better developed regions. Our change data from 2003-2010 illustrates a decrease in R&D investment in some parts of North West Europe, the northern Baltic Sea Region and the Northern Periphery (specifically Benelux, France, Germany, Poland, the United Kingdom, and Sweden). This does not bode well for maintaining and growing the innovative capacity of these regions and may be an early indicator of potential future decline (a ‘rustbelt’ scenario). The data illustrates that areas of these countries that were already lower performers have seen investment decline over the time period. If Europe is to effectively compete with its biggest global rivals – the United States (US), South Korea and Japan – it can not afford to allow particular regions to economically stagnate. While part of this decline might be offset generally by very substantial increases in other regions within the same countries and be the result of specialisation, this creates a very significant challenge in relation to social and territorial cohesion that are discussed further in the policy guidelines below.

7.2 Regions or Cities showing strengths or potential

Although some regions in France, Germany, Benelux, Poland, the United Kingdom and Sweden show a decrease in R&D investment between 2003 and 2010, North West Europe, the northern Baltic Sea Region and the Northern Periphery remain to a great extent the drivers of Europe’s smart growth or the most promising drivers of the future growth of Europe’s smart economy. In terms of R&D expenditures (expressed as a percentage of GDP) , 28 NUTS 2 regions had already reached or exceeded the overall 3% target set by the European Union over the 2007-2010 period. This is the case, for example, of the Brabant-Walloon region in Belgium and the Braunschweig region in southern Germany, which is also by far the most productive area of Europe in terms of patent applications to the EPO, a sign of the strength of its industries. This is an indicator of their high level of innovative capacity and their capacity to compete with the most innovative regions of the US, Japan or South Korea. Among the European regions with high levels of expenditure in R&D, and in addition to central Belgium and southern Germany, are parts of Sweden, Finland, Denmark, the United Kingdom, Austria, and France. In macro-geographical terms, higher levels of R&D expenditures are found in parts of the Baltic Sea Region, North West Europe, and the western part of the Danube Space. Within these spaces, some particular, transnational / transborder ‘corridors of investment’ can be identified, including a Belgian-Dutch corridor, a Copenhagen-Malmo corridor (sprawling to the Stockholm region and to most of Finland), and a geographically broader corridor extending from southern France to Austria and encompassing the Geneva region and southern Germany. These ‘corridors of investment’ tend to encompass regions with high levels of specialisation in particular industries or services that require high levels of investment in R&D in order to maintain a competitive advantage. This is the case, for example, of the aeronautical and aerospace industry in southern France (in the Toulouse area, where Airbus is located), or of the information and communication technologies (ICT) sector in Scandinavian regions.

Specialisation is important in attracting public investment in R&D, exemplified through a closer look at NBIC technologies – considered as emerging technologies with the potential to drive future growth. The index of specialisation in NBIC research highlights some major urban clusters in Europe, and very strong specialisation in nano-sciences and nanotechnologies is evident in Scotland. The British Isles (United Kingdom and Ireland) as a whole can be considered as one of Europe’s major NBIC clusters especially around towns or cities with major universities. The two other significant clusters of investment in NBIC technologies are located in the western part of the Danube Space (in Slovakia, Germany and Switzerland) and in the northern part of the Baltic Sea Region. A few outliers were also identified, such as Faro in Portugal and Compiègne in France; the presence of universities with a history of specialisation in NBIC-related fields of research in these cities is a key explanatory variable here.

Going back to R&D expenditures in general, some of the highest-spending regions are those that have increased their share of GDP devoted to R&D over the 2003-2010 period. These include a number of regions in the Baltic Sea Region, in particular in Scandinavia, a number of regions in Central Europe (in the northern part of the Baltic Sea Region and in the north-western part of the Danube Space), and regions in North West Europe (particularly parts of the British Isles, in Ireland and southern England for example). More surprisingly, among the regions with the highest positive changes in levels of R&D expenditure are several parts of the Iberian Peninsula (in particular in Portugal). These are not among the top spenders in terms of R&D; however, they have experienced important positive changes in the past decade that can appear quite dramatic and misleading if one does not take into account the very low base of R&D expenditure from which change has occurred. A general increase in Turkey, albeit a modest one – and one that certainly does not position Turkey in the league of top R&D spenders – is also noteworthy and can be interpreted as a sign that Turkey aims at 'catching up' with Europe's standards in terms of innovative capacity.

The general pattern of higher and/or increasing levels of investment in R&D as a percentage of GDP is reflected in the territorial pattern of higher levels of Business Expenditure in R&D (BERD). These are important because they represent an indicator of a country or a region's capacity to attract and retain private sector investment, of significant importance in times of economic crisis given the impact of austerity on public expenditures. Therefore, regions with higher levels of BERD are to be considered as key pillars or potential key assets in the development and consolidation of Smart Growth as defined by the Europe 2020 Strategy.

One interesting point is that high levels of R&D expenditures (in general and in terms of BERD) are not necessarily linked to high levels of urbanisation, with some rural regions rivalling some of the most dynamic metropolitan regions of Europe. In other words, the urban/rural divide is not a major determinant in terms of R&D investment. However, it does become a key variable in understanding the geographical distribution of Human Resources in Science and Technology (HRST). Large cities and metropolitan areas such as London, Copenhagen, Prague, Zurich, Utrecht, etc are clearly the European leaders in terms of HRST, employed mostly in advanced producer services, including financial services, where technology has become the key innovation. The constant development of new products is a crucial determinant of the creation and maintenance of comparative advantage and competitiveness. The presence of universities – some world-class universities, some with major research centres and spin-out companies on-site – in or around these cities (many of them national or regional capital cities / capital city-regions) is often a key advantage that provides these cities with an abundant, on site / readily available, highly qualify pool of labour. This is again fundamental in attracting and retaining inward investment and employment. Besides the availability of highly qualified workers, companies are interested in other agglomeration effects, including those specifically related to innovation such as the cross-fertilisation of ideas and expertise that is enhanced by geographical proximity, and a supportive policy-environment that might emerge from agglomeration economies that are seen as key to local and regional economic development in particular places, for example financial services in London/the UK or pharmaceuticals in Dublin/Ireland (CAEE, 2010). Beyond capital cities and their regions, all Scandinavian regions have high levels of HRST as do the British Isles and Ireland in particular, most of the Northern Periphery, North West Europe and the Atlantic Axis. This territorial pattern is roughly mirrored by the pattern of high levels of employment in knowledge-intensive services, for reasons that have been mentioned above, including the role of the ICT sector (especially in Scandinavia) and financial industries (in London and Luxembourg for example). Again, agglomeration economies are fundamental to understanding such a pattern and to understand why such regions represent crucial strengths in the development and consolidation of Europe's knowledge economy.

7.3 Policy Implications

The Territorial Agenda 2020 (2011, p. 7) for Europe argues that "the development of innovation and smart specialization strategies in a place-based approach can play a key role" in meeting the growth agenda for Europe. Vieira et al. (2011, p. 1269) have argued that in order for a region to attract foreign capital, and thus generate employment and growth, productivity is key and innovation is a major driver. This smart growth generates significant social as well as economic returns (Griffith et al., 2001; Alexiadis and Tomkins, 2008), clearly linking the smart and inclusive growth pillars of the EU2020 Strategy.

Our analysis has identified a number of strengths, weaknesses, opportunities and threats across the European territory in relation to research and innovation and the capacity of regions to meet established goals. European cohesion policy seeks to enable all regions to develop their full potential in order to promote more balanced regional development. Similar to the conclusions of the KIT project (KIT, 2012), the headline message from our analysis is that a 'one-size-fits-all' conception and approach to innovation is not appropriate and that Europe's innovative strength lies in its diverse innovative capacity. The policy implications are outlined below.

7.3.1 Defining innovation and innovative regions

- The concept of innovation being promoted and targeted in European policy is dominated by high-tech activities. Broadening the definition of 'innovation' will be critical to ensure that all regions can 'buy-in' to smart growth goals in place-appropriate ways. Knowledge-innovation (for example in agri-food, eco-tourism etc.) is not captured in the current indicators measuring innovative capacity. 'Bottom-up' innovative potential in Europe, potentially a significant source of growth for 'lagging regions' requires attention and support. A place-specific and broader definition of innovation should be developed as a priority.
- Investment in R&D as a % of GDP is a key EU2020 indicator. However, commercialization of R&D is required to produce innovation and the literature would suggest that the region where the input (R&D investment) is made is not necessarily the region where the innovation occurs. Caution must therefore be exercised by policymakers in using the R&D investment figures to define innovative regions.
- While the European Union has established a series of general policies for developing research and innovation capacity, similar development paths should not be expected from all regions. Currently, there are a number of high-performing NBIC clusters in parts of Europe characterised by specialised facilities and attributes. These should be supported to enable them compete globally but there should not be an expectation that all parts of Europe promote NBIC economic activities as a source of future growth. Targeted actions for specific parts of the European space must be developed with this in mind and

alternative, appropriate innovative indicators developed for others.

- Our analysis raises the issue of the usefulness of national targets given the diversity of regional performance even within specific countries. Given the established importance of path-dependency at regional level as well as on a macro-geographical scale, regional targets may be required. Our research demonstrates the absence of spillover effects from high-performing regions to neighbouring regions, and in some cases the potential negative effects on a ‘lagging region’ of proximity to a high-performer, strengthening the case for more nuanced goals and targets.

7.3.2 Institutional arrangements

- The role of universities appears critical in encouraging and supporting the innovation agenda in Europe. If Europe is to catch-up with other world regions such as the US and Japan, and to remain competitive and attractive in relation to the BRIC countries, austerity measures should be implemented mindful of the negative impacts that education cuts will have on the research and innovation agenda.
- Areas with a high proportion of investment in R&D generally are also those areas that have the highest proportion of Business Expenditure in R&D (BERD). The ability of private sector investment to generate and promote innovative capacity should continue to be supported as the Innovation Union flagship initiative suggests. However, it may be worth considering targeted incentives to attract BERD into lagging regions that display some innovative potential (defined through significant change in % of GDP over the time period) but that simply cannot compete on an equal footing with regions that have had a significant initial advantage.

7.3.3 Patterns of investment

- In comparative perspective, Europe appears to be lagging significantly in terms of investment in R&D activities. However, it is not clear from the policy documents and discussions whether the figures for different world regions are directly comparable. Defence spending needs to be controlled for in any comparative analysis given the significance of miliary spending in the US and South Korea for example.

- When specific national contexts are examined, the data illustrates distinctly different policies in operation. The United Kingdom appears to be favouring a specialisation agenda with some regions gaining in attractiveness and advancing significantly while lagging regions experience dis-investment and disadvantage. Polarisation is evident with distinct winners and losers in relation to research and innovation, with significant implications for social and territorial cohesion. In contrast, Germany appears to demonstrate a more redistributive tendency with R&D success in one region being transferred to others, and an important production of patent applications to the EPO across its territory. In order to ensure smart growth is aligned with inclusive growth, the European Union needs to develop coherent policy guidelines in relation to optimum paths to development that would embed R&D policy within broader territorial agendas.
- The data illustrates that cross-border co-operation or agglomeration economies are emerging in Europe in specific parts of the European territory, for example the Copenhagen-Malmo, Toulouse-Geneva-Vienna or Brussels-Breda-Eindhoven corridor. Smart growth policy should support the further development of specific clusters and encourage agglomeration in areas for example that have a high base of HRST. Developing co-operation, facilitating mobility and fostering the deepening of network activities will be key to enhancing Europe’s global competitiveness. Expanding exising strong agglomerations into the Danube space or Eastern Baltic Sea regions should be a priority.
- Currently Turkey ranks very low on most research and innovation indicators. This is not surprising given the history and economic structure of the country – including the importance of agriculture and tourism in its overall economic fabric – and the fact that all of our research and innovation indicators relate to research and innovation in science and technology and other domains of the so-called knowledge society, i.e. sectors of the economy that are not well-developed in Turkey. This does not mean that innovative capacities and investment opportunities are not present in Turkey, but they may be in the agri-food sector or in new forms of tourism, building on some of Turkey’s current strengths. In other words, and going back to our headline message in terms of policy recommendations, a monolithic understanding of and approach to developing R&D and innovation limited to particular sectors of the economy – mostly science-and-technology-based industries and

advanced producer services – may not be the most inclusive and sustainable path to smart growth in Europe.

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