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Exploring regional structural and S&T specialisation: implications for policy

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I Introduction

The interface of regional systems with national and pan-European R&D systems, particularly in the context of the Lisbon objectives, and the subsequent assessment of progress towards a more competitive knowledge economy calls for a more in-depth understanding of regional level trends and structures. The focus of this booklet is on regional scientific and technological relative specialisation patterns within the ERA, taking into account R&D investment patterns.

Does relative specialisation matter at the regional level?

This booklet examines two forms of 'output' indicators for the regions of the 27 European Union (EU27) Member States:

Relative scientific specialisation essentially captures the output of the 'academic' research system in as much as it measures performance on the basis of scientific publications across 11 fields;

Relative technological specialisation, on the other hand, looks at patenting activity, largely of the manufacturing sector, on the basis of European Patent Office (EPO) patents.

In both cases, the indexes calculated measure the result of activity in comparison to the field and world totals and say nothing about the quality of the output. Drawing conclusions about the future competitiveness of the EU27 regions from such specialisation patterns would require further research to understand how the 'outputs' of this research activity are translated into innovative products or services; and, thereby, influencing trends in value added or productivity in regional economies.

What is the policy context for taking a closer look at regional scientific and technological specialisation? The ERA Green Paper[1] argues that "*European countries and regions may build on their strengths by progressively developing specialisation in certain fields. However, they should be able to maintain or gain access to other specialist knowledge and S&T capacities in the rest of Europe and the world, notably through researcher mobility, knowledge sharing and the development of virtual networks and 'communities'*".

Why specialise? The underlying idea is that companies, and in a wider perspective also regions and countries, specialise in certain activities, which give them a comparative advantage and render them competitive (from a business or a scientific point of view). There are many factors which can explain why this specialisation process occurs: at the firm level, specialisation is driven by economies of scale, positive learning effects based on experience, marketing and reputation, etc.; while on a wider local or regional level, clustering[2] and agglomeration effects, proximity and knowledge spillovers[3], etc. help to explain concentrations of activities, and of skilled people. Thus, companies, and by analogy regions, gain a relative advantage in focusing on certain activities, helping them be

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1 http://ec.europa.eu/research/era/index_en.html

2 The classic text on clusters is: Porter, M.E. (1998): Clusters and the new economics of competition, Harvard Business Review, November-December, 77-90.

3 Key concepts within studies of regional and urban growth are the concept of knowledge spillovers, collective capabilities and processes of cumulative causation. Knowledge spillovers are localised and tend to decay rapidly with transmission across geographic space. The intensity of such knowledge spillovers is important for the growth and development of the region and is essential for the understanding of clustering and the reasons why growth rates differ between regions. Krugman, P. (1991): Geography and trade. MIT Press, Cambridge

more successful on national and international markets. At a regional level this success generates higher incomes, economic growth, employment and socio-economic well-being.

Comparative data on a number of important science and technology indicators is increasingly available and used for benchmarking purposes. However, most data, is available at the national level and hence this has been the level of analysis of specialisation based on patent and publication data[4]. A lot less is known about specialisation at the regional level. While reports in some larger Member State cover the regional level[5], this is neither done systematically nor is there a cross-country regional analysis available[6].

At national level, work has been done on examining the specialisation of public and private R&D activities[7] and such studies show that variance in intensity of inputs (investment, human resources) and outputs of R&D is greater within countries than across countries (that is between the regions of a country, than between Member States). Equally, a significant amount of research and studies have looked at regional economic specialisation[8] or mapped clustering of industrial activities[9]. However, very little research or even statistical analysis has been done at the regional level previously on scientific and technological specialisation; and what it could imply both for the effectiveness of regional, national and European research systems; and subsequently competitiveness.

Limits to analysis: regional availability of data

In the EU27, regions are defined by the NUTS (nomenclature of territorial units for statistics) classification[10], at four levels:

NUTS level 0 is the country level. The smaller countries often do not distinguish between a national and regional level;

NUTS level 1 is a broader geographic area, most often a 'statistical' grouping of administrative regions (except in Belgium, Germany and the UK, where this level corresponds to the regional government level);

NUTS 2 is the level in most countries (Bulgaria, Denmark, Greece, Spain, France, Hungary, Ireland, Italy, the Netherlands, Austria, Poland and Romania, Finland and Sweden) at which 'regional authorities' operate and/or at which regional operational programmes of the Structural Funds are designed and implemented;

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4 A detailed investigation of national specialisation patterns is the subject of another booklet in this series.

5 For instance in France, the OST biannual report on science and technology indicators; or in Germany, the BMBF report on Germany's technological performance.

6 Benchmarking data on a wider set of indicators is available in the 2006 Regional Innovation Scoreboard http://www.proinno-europe.eu/ScoreBoards/Scoreboard2006/pdf/eis_2006_regional_innovation_scoreboard.pdf

7 Dinges M. et al (2007), Monitoring sector specialisation of public and private funded business research and development. Science & Public Policy 34(6).

8 Such analysis generally starts from one of three theoretical strands: firstly, the classical Heckscher-Ohlin theory determines that each territory will specialise in industries which are intensive in the factors with which it is abundantly endowed; secondly, the new trade theories show that each country or region will produce less product varieties within an industry to take advantage of increasing returns to scale; and thirdly, the new economic geography theories show that vertical linkages between industries will result in the agglomeration of these industries in the one location.

9 http://www.clusterobservatory.eu/

10 http://ec.europa.eu/eurostat/ramon/nuts/introduction_regions_en.html

while NUTS 3 is usually equivalent to the local authority (district) or city level[11].

Hence, there are significant differences in the existence (or not) of NUTS1 and NUTS2 levels; and between the NUTS level at which regional authorities have (more or less) policy-making powers and budgetary means to support or facilitate investment in R&D. For an inter-regional comparison of scientific and technological specialisation indicators, the differences notably in the availability, reliability and timeliness of data at NUTS 1 or NUTS2 levels are critical.

The main problems faced are data availability in general and the timeliness of available data, in particular. Regional data, at whatever sub-level, is collected via decentralised authorities, transferred to regional or national statistical offices and then to the European level (Eurostat). This leads to a number of issues: firstly data is not always available at NUTS 1 or 2 levels via the Eurostat database even for countries where this statistical level is defined (i.e. it is either not aggregated or disaggregated by national statistical offices and communicated to Eurostat)[12]. Secondly, while it may be possible to obtain the latest harmonised country level data from Eurostat say for 2006, data for the same indicator on the regional level may only be available for 2003[13].

[11] Smaller administrative units below NUTS3 exist in almost all countries (communes, municipalities, towns, wards, etc.) are often a level at which local services are delivered.

[12] In addition, for some indicators, Eurostat marks the data as unreliable. In these cases, the regional data was not used in this booklet.

[13] At NUTS 0 (country level) data is more recent and has been used previously in the 'Key Figures' series. Hence, the current booklet excludes the presentation similar country level data for most indicators. For example R&D intensity for all EU Member States is available for 2006 and included in the Key Figures 2007 edition. R&D intensity on the NUTS 1 regional – level was only available for 2003 at the time of drafting this booklet. Therefore, only regionalised data available for 2003 is included here.

Accordingly, regionalised, validated science and technology data is unfortunately less available than would be the case in an ideal world. From a policy-making perspective, a main drawback when analysing regional indicators is that they may refer to data that is three or four years 'old'. This clearly does not facilitate a description or analysis of the most recent structures or trends. Hence, drawing policy conclusions based on indicators using relatively old data is not advisable. The question then is at **which level can an analysis of scientific and technological specialisation be 'effectively' carried out** (in order to provide relevant and robust information to policy-makers).

In a first instance, the analysis (including the averages calculated for the regions) presented in this booklet focuses on 85 NUTS 1 regions (for a full list, see table A1 in annex). At this level, the highest number of regions have the most up-to-date data available. However, a regionalised analysis using NUTS1 level data has the disadvantage, that 11 EU Member States do not distinguish between NUTS 0 and NUTS 1 level (see table below).

Clearly this approach is not optimal since, for example, it limits the calculation of the EU regional average to regions of 16 countries[14]. However, since publication data is not available below NUTS1, and patent applications are too few in many regions at NUTS2 level to make a specialisation calculation robust, **it is the level at which the largest number of regions can be most effectively compared**. Nevertheless, available data at NUTS2 level for the top 100 NUTS2

[14] Although the NUTS 1 level exists for Bulgaria and Sweden, data required for calculating science and technology specialisation is not available.

regions in terms of patent applications is examined in order to enrich the analysis.

In short, this booklet uses the RKF-database (see footnote 1) and presents available data and analyses on a small number of highly relevant indicators which taken together, provide a snapshot of those EU27 regions that score continuously well and those at risk of falling behind in terms of their scientific and technological capacities.

The booklet is structured as follows:

Chapter II presents briefly key indicators on R&D structures. The aim is to provide a baseline understanding of the positioning of the NUTS1 regions in terms of their regional research systems against which their scientific and technological specialisation can be compared[15].

Chapter III considers the scientific and the technological specialisation of the EU27, drawing on both, scientific publications and patent applications. This is done for each type of index at the level for which data is most widely and robustly available (NUTS0, NUTS1, or NUTS2);

Finally, the booklet concludes with a summary of the key conclusions to be drawn and pointers to policy implications and needs for further research.

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15 A separate booklet on Europe's Regional Research Systems (RKF 1-2008) provides a much more in-depth examination of available data at NUTS2 level.

Figure I-1 Statistical regions in the EU27

Countries with NUTS 1 level regions (numbers in brackets):	Countries <u>without</u> NUTS 1 level but with NUTS2 level regions:	Countries <u>without</u> defined NUTS1 or NUTS2 level regions:
Austria (3) Belgium (3) Bulgaria (4) Finland (2) France (9) Germany (16) Greece (4) Hungary (3) Italy (5) Netherlands (4) Poland (6) Portugal (3) Romania (4) Spain (7) Sweden (3) UK (12)	Czech Republic, Denmark, Ireland, Slovenia, Slovakia.	Estonia, Latvia, Lithuania, Malta Cyprus, Luxembourg

For the full list of regions, please see Annex 1.

II Regional R&D systems: structural profiles

Do regional specialisation patterns differ from national ones; and if so, in what ways? Previous studies suggest that regions even within countries differ often significantly. However, industrially strong regions and their technological specialisation profiles influence largely national profiles. While country level profiles are clearly the sum of their parts, the average country performance hides strong regional divergence in performance. Understanding, these variations in performance, and the factors that provoke them, should be at the heart of a regional approach to research policy.

The chapter looks therefore at a key set of structural R&D indicators, which include R&D intensity (R&D investment), sectors of R&D performance and employment in high-tech sectors.

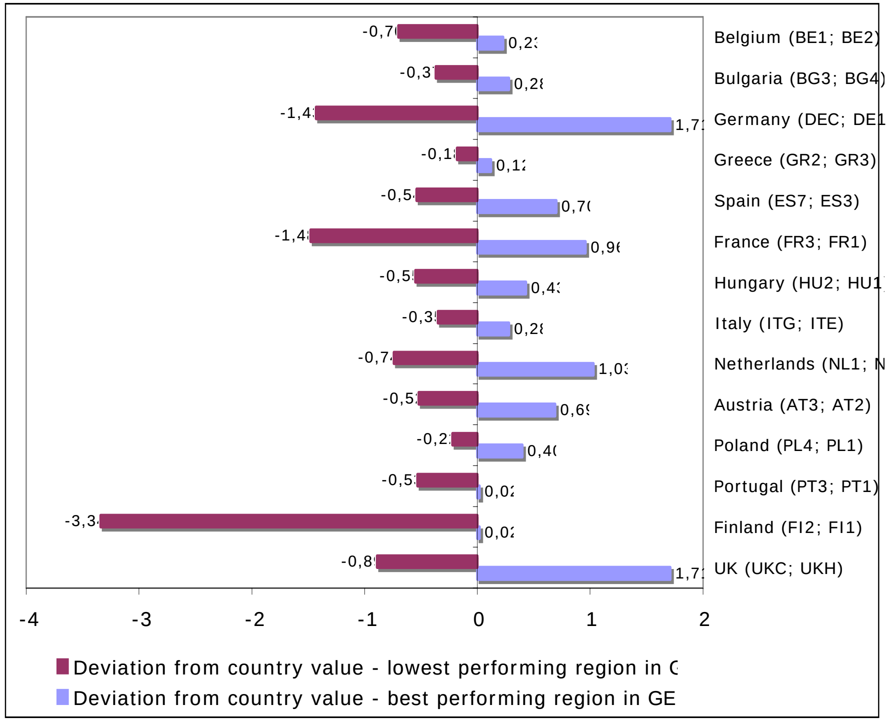
II.1 Regional investment

A wide variation in patterns of regional investment in R&D

In 2005, R&D intensity (GERD as a % of GDP), at the national level, varied from 0.39% in Romania to 3.86% in Sweden. However, at a regional level, the variance is even bigger: the lowest R&D intensity was in *Severna i iztochna*, Bulgaria, at 0.12%, while the highest percentage was in the German land of *Baden-Württemberg* with 4.19%. A great deal of the variance can be explained by the size and geographic situation of the region: at NUTS1 level, Finland, for example, is split into two regions: in terms of size, the 'macro'-region Finland comprises 5.2m inhabitants while the island region Åland is inhabited by only 26,000 people.

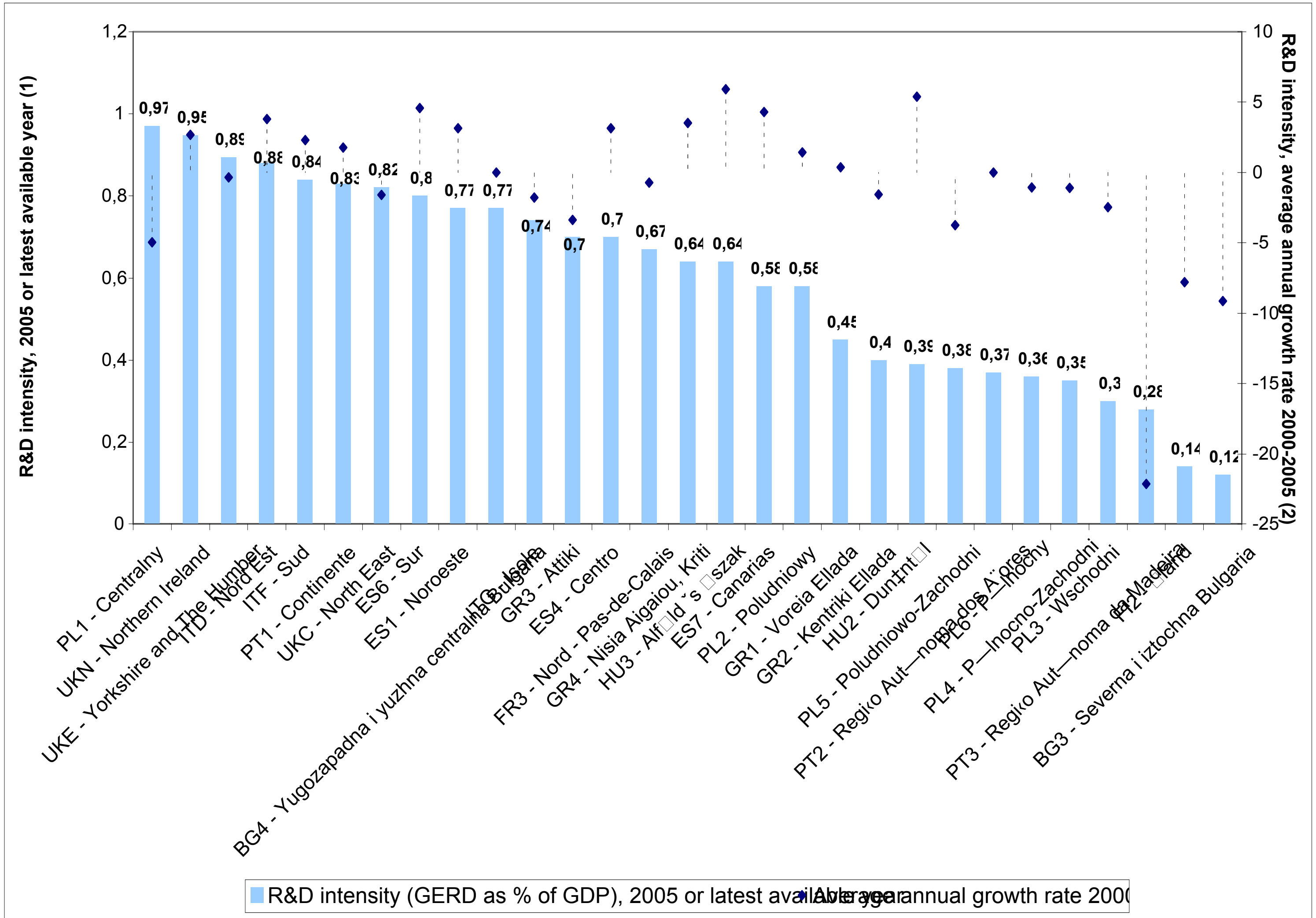
Considering the intra-country regional differences (Figure II-1), regions in the larger Member States (Germany, France, and the UK) display a relatively strong divergence from the national average than in smaller countries such as Greece or Belgium.

Figure II-1 Highest and lowest R&D intensity (GERD as % of GDP) in European regions per country, 2005



Source: DG-Research Regional Key Figures 2008
Data: Source: integrated Eurostat/OECD data, + Value 2004 for the UK regions coming from ONS population Trends Winter 2006 Tables 1.3 and 1.4 and ONS)
(1) FR, AT, UK: 2004
Data Treatment: Technopolis Group

Figure II-2a R&D intensity (GERD as % of GDP) below 1% in EU27 regions (NUTS1), 2005 (1) and average annual growth 2000-2005 (2)



Source: DG-Research Regional Key Figures 2008; Data: Eurostat; Data Treatment: Technopolis Group
Notes: (1) FR, AT, UK: 2004, (2) BE:2002-2005; DE:1999-2005; FR:2000-2004; AT:2002-2004; UK:1999-2004, (3) EU average: based on available regions

Using R&D intensity, regions can be classified into three to four groups. Out of the 79 NUTS1 regions for which data is available, 50 (63%) had an R&D intensity of at least 1% in 2005 while 29 regions fell below this level (Figure II-2a). The 50 regions above 1% can equally be split into those with a R&D intensity between 1-2% and those above 2% (Figure II-2b and II-2c). The average NUTS1 regional R&D intensity was 1.47% in 2005 and the average growth rate was -0.15% from 2000-2005. While the most significant negative growth was recorded for *Madeira* (-22%), the highest positive growth took place in the German Land of *Mecklenburg-Vorpommern* with 6.43%.

Peripheral regions fail to catch up in R&D intensity race

The 29 regions with the lowest R&D intensity are from 10 EU Member States (BG, EL, ES, FI, FR, HU, IT, PL, PT and UK). Ten out of the 29 regions are from new (since 2004) Member States: six from Poland and two each from Bulgaria and Hungary. The average R&D intensity growth during the 2000-2005 period in this group was 0.67%, with a low in *Madeira* (PT) (-22.16%) and a high in *Alföld és Eszak* (HU) (5.92%).

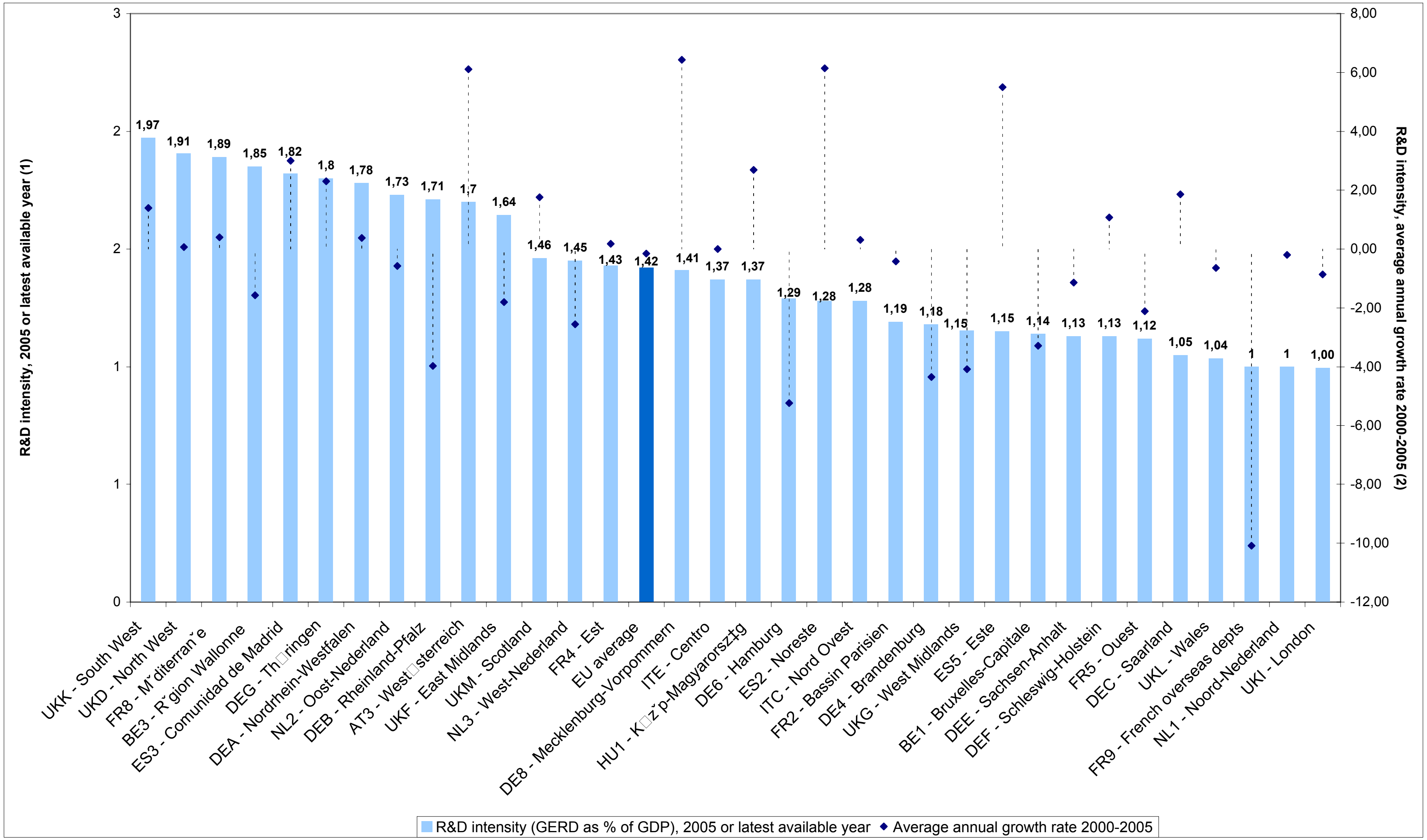
Considering the geographical characteristics of the regions with an R&D intensity below 1%, it is evident that that they tend to be located in the periphery (with the exception of the Greek *Attiki*), either of the country they are located in (e.g. *Alföld és Eszak* in eastern Hungary, UK *North-East*, *Northern Ireland* or the French *Nord–Pas de Calais*) or at European level (Portugal's *Continente* or the Finnish *Åland*, the Spanish *Canary Islands* or the Italian islands).

Even middle-to-high R&D intensity regions had slow growth

The second, much larger, group of regions with a R&D intensity between 1% and 2%, consists of 30 regions located in nine countries (AT, BE, DE, ES, FR, HU, IT, NL, UK) (Figure II-2b). Only one region from the new Member States, from Hungary, makes it into this group. R&D intensity ranges from 1% in *London* up to 1.97% in the UK's *South-West* region. The average R&D intensity in this group was 1.41%. In terms of growth rates, the figures range from -10.09% in the French *Overseas Departments* up to 6.43% in *Mecklenburg-Vorpommern*. The group's average growth rate was slightly negative with -0.1% between 2000 and 2005.

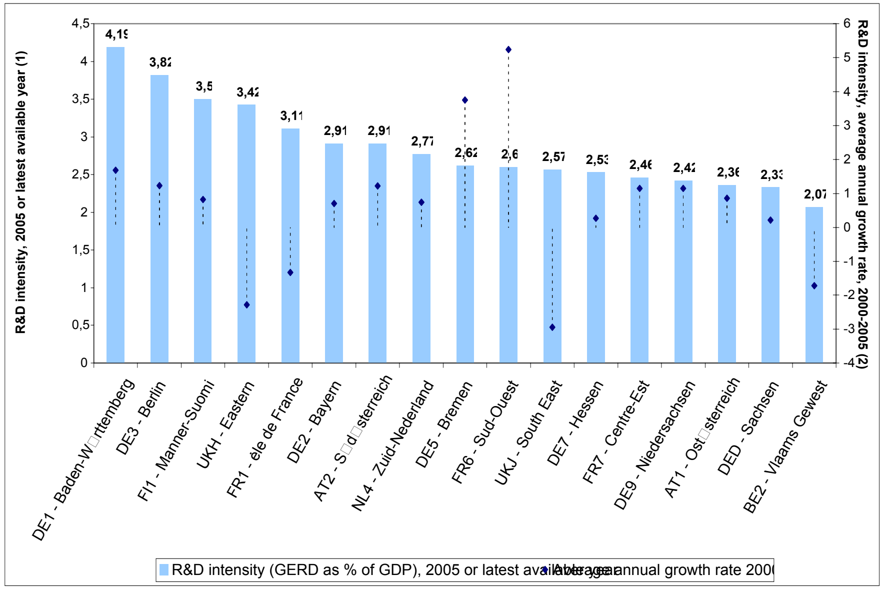
Finally, the smallest group of regions is those with a high R&D intensity (Figure II-2c); 17 regions from seven countries (AT, BE, DE, FI, FR, NL, UK). Its average R&D intensity in 2005 was 2.86% and it had a growth rate of 0.63% between 2000-2005. At the level of individual regions, the lowest R&D intensity in 2005 was recorded for the Belgian *Vlaams-Gewest* with 2.07% and the highest in Baden-Württemberg (DE) at 4.19%. In terms of growth rates, even in this group negative growth rates were encountered: the lowest growth was recorded for the UK *South East* (-2.94%) and the highest in the French *Sud-Ouest* with 5.73%.

Figure II-2b Regions with an R&D intensity (GERD as % of GDP) between 1-2%, 2005 (1) and average annual growth 2000-2005 (2)



Source: DG-Research, Regional Key Figures 2008, Data: Eurostat, Data Treatment: Technopolis Group
Notes: (1) FR, AT, UK: 2004, (2) BE:2002-2005; DE:1999-2005; FR:2000-2004; AT:2002-2004; UK:1999-2004, (3) EU average: based on available regions

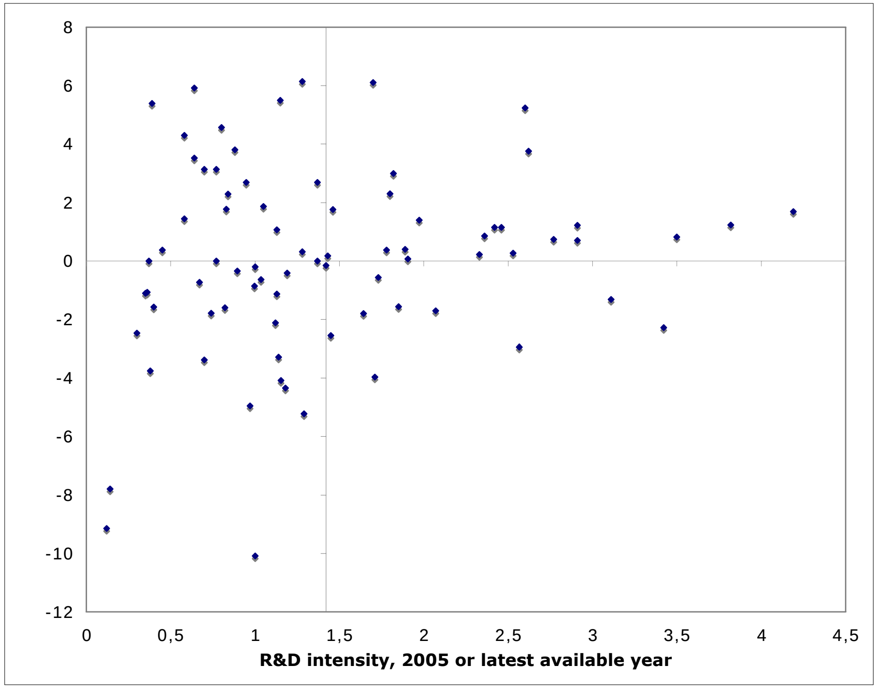
Figure II-2c Regions with an R&D intensity (GERD as % of GDP) above 2%, 2005(1) & average annual growth rates 2000-2005(2)



Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis Group
Notes: (1) FR, AT, UK: 2004
(2) BE:2002-2005; DE:1999-2005; FR:2000-2004; AT:2002-2004; UK:1999-2004
(3) EU average: based on available regions

Comparing R&D intensities and growth rates (Figure II-3), and taking the regional average of the 79 NUTS1 regions, as a benchmark, it is apparent that less than half of the regions (31) are above the average in 2005 and 34 regions showed a negative growth rate. A negative growth rate combined with less than regional average shares in 2005 can be found for about 25 regions from 11 Member States (BE, BG, DE, FI, FR, EL, IT, NL, PL, PT, UK).

Figure II-3 R&D intensity, 2005 (1), and average annual growth rates 2000-2005 (2)



Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis Group
Notes: (1) FR, AT, UK: 2004
(2) BE:2002-2005; DE:1999-2005; FR:2000-2004; AT:2002-2004; UK:1999-2004

3% of GDP on R&D...the goal is not widely met

In short, the 3% GERD/GDP target, set at the Barcelona summit in 2002, is even more difficult to achieve across the EU regions than at the national level. Only five regions match the 3% target: UK's *Eastern*, Germany's *Berlin* and *Baden-Württemberg*, *mainland Finland* as well as the *Île-de-France*. Indeed, as noted above, only 31 regions out of 79 are above the EU regional average of 1.47% of GDP spent on GERD. In this context, it is important to understand the role of the different sectors of expenditure and performance.

The variance in business expenditure on R&D: a key factor

A first question is how does the amount invested by the business sector in R&D vary across regions? In 2005, the EU regional average was €1,242m (in pps 2000), however the variance ranged from €9,319m in *Baden-Württemberg* and €0.2m pps in *Azores*. The top ten regions all spent more than €2,700m.

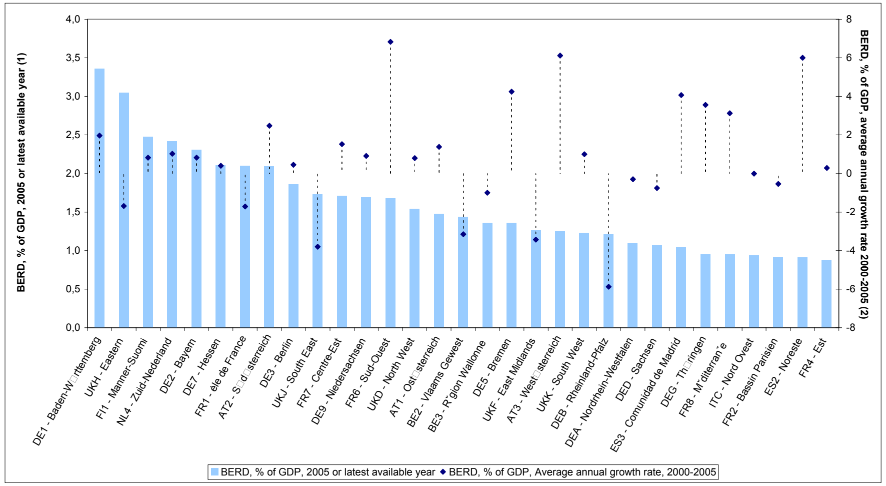
Table II-1 Business R&D expenditure in €m pps 2000: Highest and lowest spending regions 2005

Top spending regions	€m	Least spending regions	€m
DE1 - Baden-Württemberg	9319,4	PT3 - Região Autónoma da Madeira	1,8
DE2 - Bayern	7819,5	PT2 - Região Autónoma dos Açores	0,2
DE7 - Hessen	3600,0	HU2 - Dunántúl	42,9
DEA - Nordrhein-Westfalen	4568,8	GR4 - Nisia Aigaiou, Kriti	8,8
FI1 - Manner-Suomi	3226,1	GR2 - Kentriki Ellada	34,6
FR1 - Île de France	8386,4	GR1 - Voreia Ellada	42,6
FR7 - Centre-Est	2766,5	FI2 - Åland	0,5
ITC - Nord Ovest	3958,7	ES7 - Canarias	48,3
UKH - Eastern	3976,4	BG4 - Yugozapadna i yuzhna centralna Bulgaria	50,4
UKJ - South East	3792,9	BG3 - Severna i iztochna Bulgaria	8,1

Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis Group

Analysing the regions by sectors of performance (business, public, higher education) leads to different clusters (Figure II-5). In 2005, the regional average for the business sector was 0.83% making it the dominant R&D performer. While in 47 regions (roughly 60% of the total) the business sector's share (BERD) was below the regional average, the remaining 32 regions were above average. The business sector's share ranged from 0% in the *Azores* to 3.36% in *Baden-Württemberg*.

Figure II-4 Region with above average business expenditure on R&D (BERD), 2005(1)

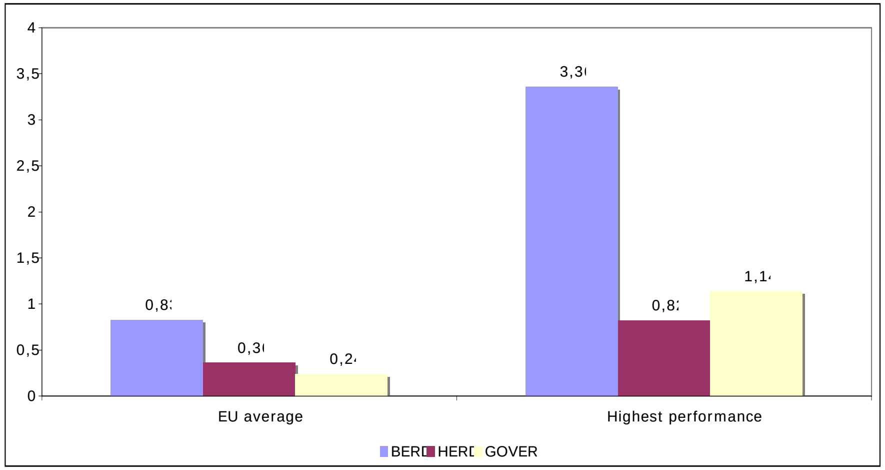


Source: DG-Research Regional Key Figures 2008
Data: integrated Eurostat/OECD data
Data Treatment: Technopolis Group
(1) FR, AT: 2004, (2) BG: 2003-2005; DE, GR: 1999-2005; FR: 2000-2004, AT: 2002-2004
EU average: based on available regions

The second most important performer was the higher education sector (HERD) with a regional average of 0.36%. Again, 37 regions were above the regional average while 42 regions were below average. The lowest share was recorded in *Åland* with 0% and the highest with 0.82% in *Berlin*. Of course, certain regions do not host a university; explaining the marginality of the higher education sector.

The government sector (GOVERD) is in several countries more important than the educational one, for others, it is the least important. In general, the public sector regional average share is low at 0.24%; ranging from 0% in North-East England to 1.14% in Berlin.

Figure II-5 Regional dispersion of GERD by sector of performance 2005 (1)



Source: DG-Research Regional Key Figures 2008
Data: Eurostat / OECD
Data Treatment: Technopolis Group
(1) HERD: FR: 2004; NL: 2003
(2) GERD: FR, AT, UK: 2004
(3) BERD: FR, AT: 2004
(4) GOVERD: FR, AT: 2004

Private non-profit organisations as a performing sector do not play a significant role at regional level, only 13 regions report a small share, the highest being 0.07% in Portugal's *Azore*.

A striking result is the relatively strong role of the government sector as a performer in the laggard regions, the opposite being the case for those regions with a high GERD share (where the business sector dominates). Looking at the top 10 regions in terms of GERD as a share of GDP (Table II-1), eight of these regions are equally among the top 10 regions in terms of GERD as performed by the business sector.

In other words, there is a correlation between a high overall GERD and strong role of business sector as the performer of R&D. From Table II-2 it can be seen that four regions were also among the top 10 for the higher education sector performance.

Concerning the government sector, only two German regions (*Berlin* and *Bremen*) out of the top 10 for R&D intensity, boast a strong government sector while at the other extreme the Austrian region of *Südösterreich* has a very low government sector performance.

Table II-2 highlights that the performance of the business sector is quite concentrated in a few Member States. Indeed even if the list is extended to those regions above the regional average, there are only regions from nine Member States: 10 German, six French, four UK, two Austrian, Belgian and Spanish regions and one each for Italy, Finland and the Netherlands.

Table II-2 Top 10 regions of GERD performed by the business sector, 2005 (1)

	GERD as % of GDP	BERD as % of GDP	HERD, % of GDP	GOVERD, % of GDP
DE1 - Baden-Württemberg	4,19	3,36	0,42	0,41
DE3 - Berlin	3,82	1,86	0,82	1,14
FI1 - Manner-Suomi	3,5	2,48	0,67	0,35
UKH - Eastern	3,42	3,05	0,47	0,35
FR1 - Île de France	3,11	2,10	0,52	0,45
DE2 - Bayern	2,91	2,31	0,31	0,25
AT2 - Südösterreich	2,91	2,09	:	0,11
NL4 - Zuid-Nederland	2,77	2,42	0,31	0,05
DE5 - Bremen	2,62	1,36	0,63	0,63
FR6 - Sud-Ouest	2,6	1,68	0,45	0,46

Source: DG-Research Regional Key Figures 2008
The yellow fields indicate the regions among the top 10 by sector of performance
Source: DG Research Regional Key Figures 2008
Data: Eurostat / OECD
Data Treatment: Technopolis Group
(1) HERD: FR: 2004; NL: 2003
(2) GERD: FR, AT, UK: 2004
(3) BERD: FR, AT: 2004
(4) GOVERD: FR, AT: 2004

The opposite can be stated for the regions with the lowest share of GERD in % of GDP (table II-3) since they are also those with the lowest shares attributed to the business sector and higher education as sectors of performance. Among the 10 regions with the lowest GERD as a % of GDP, four are from Poland, two from Portugal, and one each from, Bulgaria, Greece, Hungary and Finland.

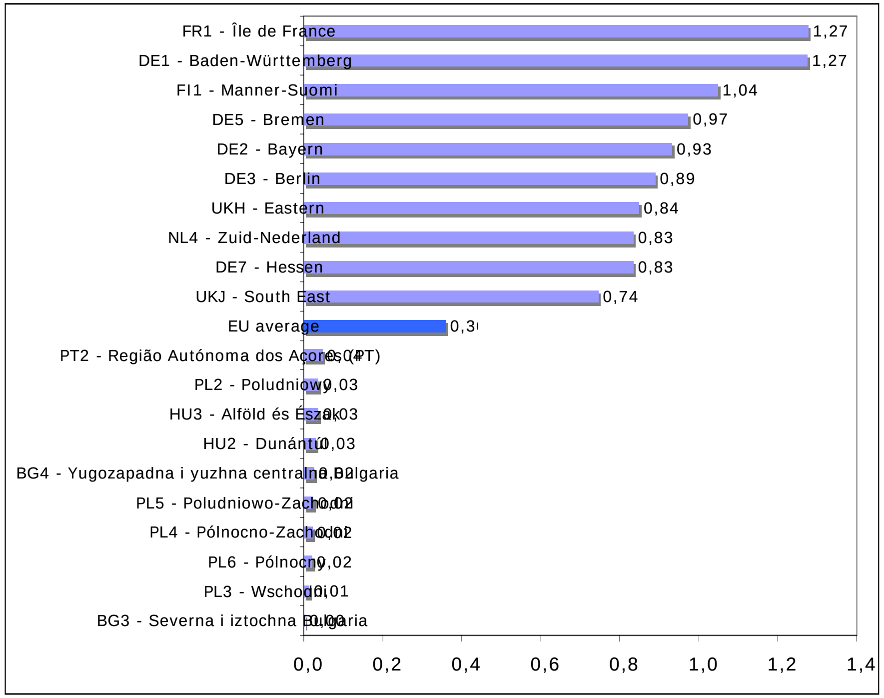
Table II-3 10 regions with lowest level of GERD, performed by the business sector, 2005

	GERD as % of GDP	BERD as % of GDP	HERD, % of GDP	GOVERD, % of GDP
GR2 - Kentriki Ellada	0,4	0,09	0,28	0,03
HU2 – Dunántúl	0,39	0,12	0,19	0,08
PL5 - Poludniowo-Zachodni	0,38	0,14	0,18	0,05
PT2 - Região Autónoma dos Açores	0,37	0,01	0,22	0,08
PL6 – Pólnocny	0,36	0,16	0,13	0,07
PL4 - Pólnocno-Zachodni	0,35	0,09	0,15	0,11
PL3 – Wschodni	0,3	0,13	0,12	0,05
PT3 - Região Autónoma da Madeira	0,28	0,04	0,08	0,16
FI2 – Åland	0,14	0,06	0,00	0,08
BG3 - Severna i iztochna	0,12	0,03	0,01	0,08

Source: DG-Research Regional Key Figures 2008
Data: Eurostat
Data Treatment: Technopolis Group
Notes: The yellow fields indicates that region is among the lowest 10 by sector of performance

There is little change in the order if population is taken into account. Figure II-6 displays the 10 regions with the highest GERD by population, the EU regional average and the 10 lowest regions. However, *Île-de-France* is now leading; and two regions are replaced in the top 10 – *Südösterreich* and *Sud-Ouest France* by *Hessen* (DE) and *South-East UK*.

Figure II-6 Highest and lowest Gross domestic expenditure on R&D (GERD) (2005), in % by population (in thousand)



Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis Group
(1) FR, AT: 2004, UK: 1999, EU average: based on available regions

The indicators on R&D intensity and GERD as a share of GDP lead to a clear stratification of regions, in particular between core and peripheral regions (both geographically core/peripheral within a country or centre/periphery in the EU27).

Within the old (pre-2004) Member States, there are a number of peripheral regions with very low R&D intensities. Many of these regions are islands such as the Portuguese *Madeira* and *Azores*, some Greek and Italian islands, or the Finnish *Åland* islands.

Within the new Member States, R&D intensity and spending generally remains lower than average and lower than the regions in the old EU15. So far, only the NUTS1 Közép-Magyarorszag (Budapest) region seems to be ‘moving’ to join the ‘Blue Banana’ regions[16]. However, at a lower NUTS level, cities such as Prague or Warsaw clearly stand out as higher performers.

Geographical location, however, is certainly not the only explanatory factor. The intensity of R&D performance by the business sector depends on a number of structural factors such as the degree of industrialisation, the presence of certain industrial sectors; the scale of firms (the number of employees, R&D personnel, etc.).

16 The term was initially coined by French geographer Brunet in 1989 to describe the curved zone stretching from the centre of England through the low countries, Paris, the Ruhr, etc. to Milan in the south. It covers one of the world's highest concentrations of people, money, and industry. It has also been used to characterise the regions with very high R&D intensities and a high business expenditure on R&D, the area between Milan and London, containing Northern Italy, Southern Germany, South East France, the Ruhr area, the Île de France, Belgium, the Netherlands and South East England

II.2 Regional employment

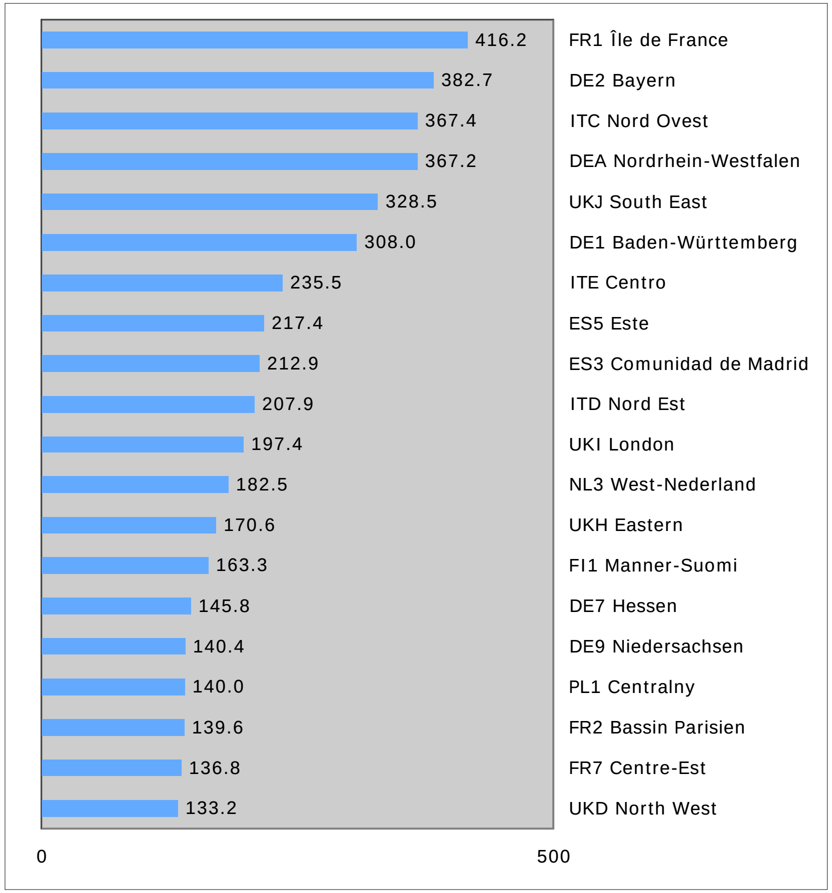
A proxy for the importance of industry as a factor driving R&D in a region is the share of high-tech employment in total employment and R&D employment. Although, low and medium-low-tech industries still provide income for many Europeans, it is high-tech industrial sectors and knowledge-intensive services that provide a basis for future competitiveness. It is obvious that not all regions can be based on high-tech industries or knowledge-intensive services only. However, those that manage to either maintain an important degree of high-tech employment or show strong growth rates of high tech employment compared to overall employment figures are likely to be better positioned.

Figure II-8a and II-8b, as well as II-9 examine high-tech employment and employment in knowledge-intensive services. In terms of absolute numbers, the regions with the largest number of high-tech employees in 2006 were the *Île de France* with 416 000 employees, followed by *Bayern* (382,000), and Italy's *Nord Ouest* (367,000) (Figure II-7a).

While the average (for 79 regions) is 106,800 high tech employees per region, only 29 regions are above this figure. The top 20 regions, in Figure II-8a, are obviously also highly populated ones. None of them has less than five million inhabitants, half of them even more than 10 million. They are not only among the highest populated regions, but they equally are leading in terms of R&D intensity and R&D performed by the business sector.

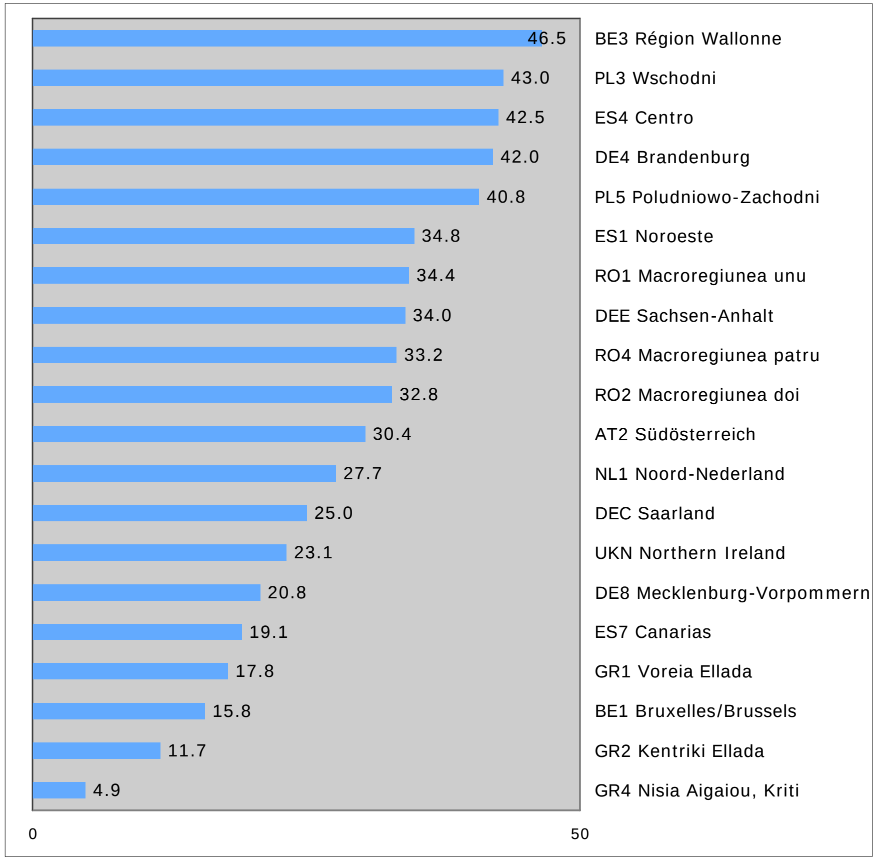
However, a large population is not enough to generate an important number of high-tech employees; and a number of regions amongst the top 15 populated regions do not appear in the list of top 20 high-tech manufacturing employment regions (Italy's *Sud*, mainland Portugal, the Spanish *Sur* and the French *Ouest*.

Figure II-7a Employment in high-tech manufacturing and in knowledge-intensive services 2006: top 20 regions (in 1,000)



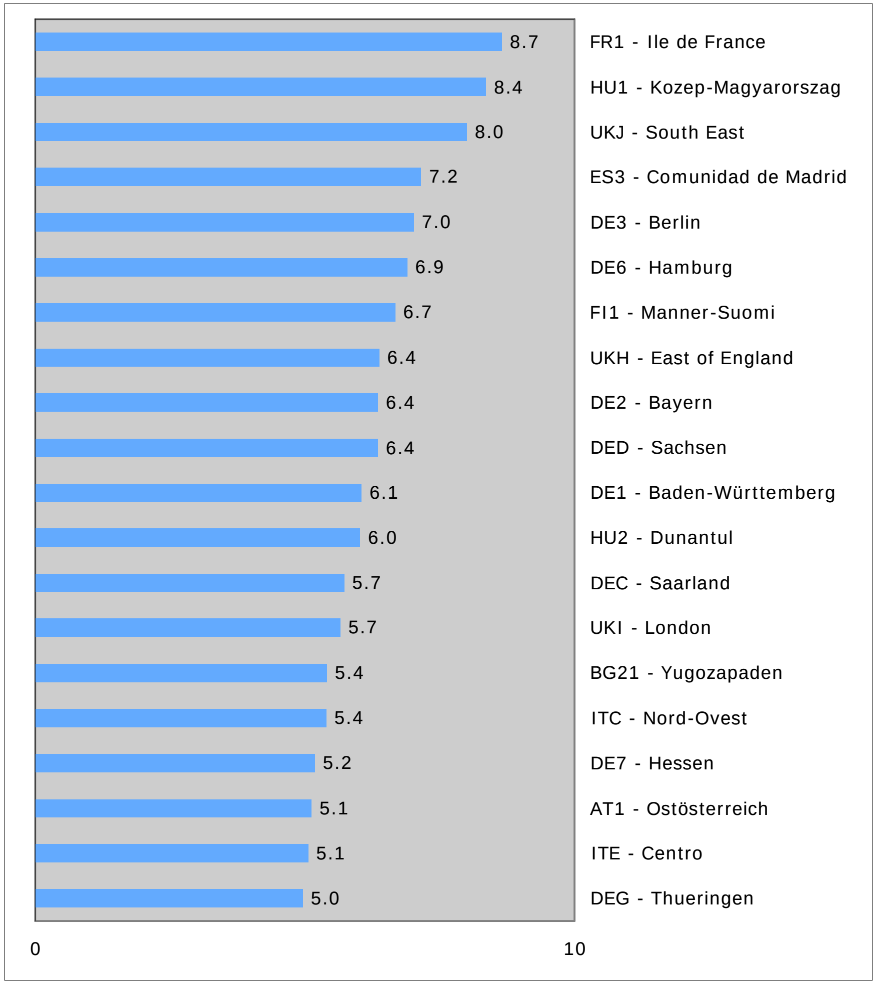
Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis Group

Figure II-7b Employment in high-tech manufacturing and in knowledge-intensive services 2006: 20 lowest regions (in 1,000) (1)



Source: DG-Research Regional Key Figures 2008
Data: Eurostat; Data Treatment: Technopolis Group
Notes: (1) in 1 000, BE: 2005

Figure II-8 Share of high-tech manufacturing employment and employment in knowledge-intensive services as share of total employment 2006: top 20 European regions (in %)



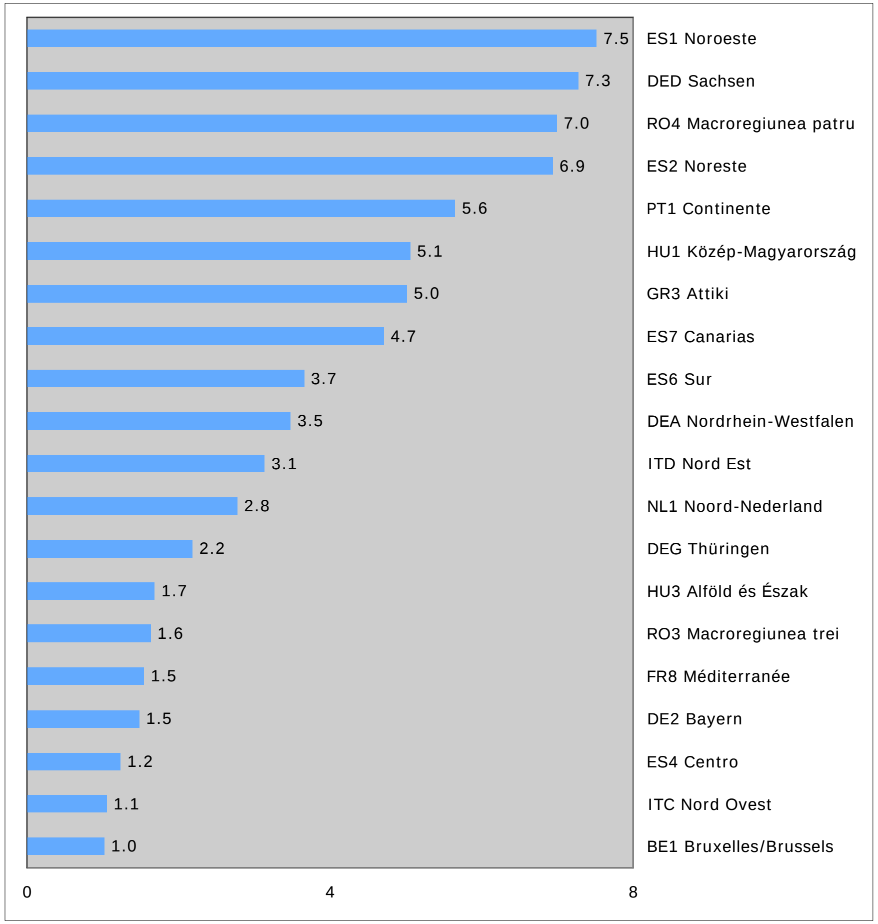
Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis Group

Among the regions with low high-tech employment (Figure II-7b), several are also laggards for a range of indicators. However, others such as *Brussels* appear in this list due to the small absolute size of the region. Indeed, while the total number of high-tech employees is certainly an important indicator in terms of understanding where the concentrations of 'knowledge workers' are forming, the share of high-tech employment in overall employment (Figure II-8) is clearly more relevant since smaller regions with lower absolute but higher relative numbers of high-tech employees will be more visible.

Most of the regions shown in Figure II-8 are 'the usual suspects': regions hosting large parts of high-tech industry as well as knowledge-intensive services. 11 regions were equally included in Figure II-7a, however, *Hamburg* and *Brussels* which were found amongst the bottom 20 regions in absolute terms are now included in the top 20 regions from a relative point of view.

Other regions, which were not included when only looking at absolute figures are the Hungarian regions of *Közép-Magyarország* and *Dunántúl*, Germany's *Sachsen*, *Berlin*, and *Hamburg*, Austria's *Ostösterreich*, France's *Méditerranée* and the Dutch *Zuid-Nederland*. On the other hand, two Italian regions, *Centro* and *Nord Est*, the Dutch *West-Nederland*, the Spanish *Este*, the Polish *Centralny*, the German *Niedersachsen* as well as the French *Bassien Parisien* and *Centre-Est* are not any more among the top 20 regions. All the latter regions are among the large ones, while the new entrants are population-wise small and medium-sized regions.

Figure II-9 Growth of share of employment in high-tech manufacturing and in knowledge-intensive services in total employment 2000-2006: leading 20 European regions (in %)



Source: DG-Research Regional Key Figures 2008
Data: Eurostat, Data Treatment: Technopolis GroupIII. Specialisation in S&T

Finally, in order to see if employment in high-tech and knowledge-intensive service sectors is effectively gaining in importance, the growth of the share of these sectors relative to total employment can be considered. Figure II-9 shows the 20 regions with the highest growth in the share of high-tech employment between 2000-2006. Only these 20 regions achieved growth rates above 1%. They are relatively widely dispersed in the EU27: a number of Mediterranean regions but also some from Germany, Hungary and Romania. Of course, several are small regions in terms of total employment such as the *Canary Islands*; however, the growth rates indicate that high-tech employment and employment in the knowledge-intensive services is growing even in less central and smaller European regions.

Key conclusions

This chapter has positioned the EU27 NUTS1 regions in terms of a number of key structural R&D indicators, the evidence suggests that:

During 2000-2003, growth of R&D performed was concentrated in a few centrally located regions while in most of the other regions growth has stagnated or even declined.

A striking result is the relatively strong role of the government sector as a performer in the laggard regions, the opposite being the case for those regions with a high R&D intensity where the business sector dominates.

Equally high-tech manufacturing and knowledge intensive services employment is strongly concentrated in a group of top 20 regions; however relative numbers and growth rates point to a more diversified picture with smaller and less central regions also making headway in shifting to the 'knowledge-economy'.

These broad figures tell a story about the size of and the intensity of effort but little about "what is being done" and of course nothing about the quality of the research funded. However, the available indicators underline the heterogeneity at regional level in terms of R&D investment; which explains to some extent the output variables analysed in the next chapter. While large countries may be active across all industries, even these countries tend to specialise in selected industries. If this is true for a large country, it is even more a fact-of-life for smaller countries, and obviously regions.

While the French Mediterranean region is famous for the aircraft industry or the German region Baden-Württemberg for the automobile industry, the specialisation of a wider number of regions is less well "known". A more in-depth understanding of specialisation can be mapped by looking at science, and, in particular, technology indicators. While patents are largely the output of industrial R&D, countries and regions also have scientific profiles in terms of the specialisation in scientific publications by broad scientific field or discipline. Given the context of the regional R&D structure, the next chapter presents shifts in S&T specialisation profiles over time in the EU27.

III Relative S&T specialisation

Definition

Relative scientific (technological) specialisation can be defined as the scientific (technological) performance of a country in a specific scientific field (technology) relative to its overall international (scientific) technological performance. As a parameter to determine publication and patent specialisation, the Revealed Comparative Advantage (RCA) methodology according to Balassa's formula (1965) is used. This RCA value has the following definition:

$RCA_{ki} = 100 \text{ x } \tanh \ln \{(A_{ki}/\sum iA_k)/(\sum_k A_{ki}/\sum_{ki} A_{ki})\}$

with A_{ki} indicating the number of publications (patents) of country *k* in the field *i*, whereby field is defined by scientific fields (patent classes). LN centres the data around zero and the hyperbolic tangent multiplied by 100 limits the RCA values to a range of +100 to -100.

Positive values for field *i* point to the fact that the field (patent class) has a higher weight in the portfolio of the country than its weight in the world (all publications (patents) from all countries taken together). Negative values indicate specialisation of A below the average, respectively. Values around zero – negative as well as positive – are distinguished from a positive or negative specialisation and labelled 'as expected' or 'world average'. This indicates that the calculated share equals the mainstream – the world average. The RCA indicator allows the assessment of the relative position of a field *i* in a country beyond any size effects. Neither the size of the field nor the size of the country has an impact on the outcome of this indicator. Therefore, it is possible to directly compare countries and fields.

What does this imply? A country L which publishes a total of 1000 publications in a given year, with a distribution of say 200 publications in field A (20%), 300 in field B (30%), none in field C, 10 (1%) each in field D, E, and F, and the remaining 470 (47%) in field G would, looking at these absolute figures, be specialised in field G, as it has the highest absolute number ad highest share in this field. A country M, which publishes 100 publications may have a similar distribution, but at a smaller scale. Again, one would say that it is specialised in G, even if the total number is only 47 publications in G, which again is 47%. Relative specialisation sets into relation the country shares (total and by field) to world figures: (total number of all publications as well as the total number of publications per field). The same applies to technological specialisation.

To be positively or negatively specialised in a given technology or scientific field, a country or region needs to divert from the world average, In the above mentioned case, if A makes up 10% of all fields and G accounts for 50%, country L may end up being relatively specialised in A rather than in G.

Implications for Policy

Policy makers often cite absolute figures as they seem to show simply where countries (or regions) are strong, but in terms of international competitiveness, the relative specialisation is more telling: is a country/region below, above or close to the world average?

While this is certainly important for technology, it can be argued that a relative scientific specialisation is less important to construct and observe, given that publications are not really linked to economic performance. One may also argue, that scientific publications depend largely on the existence of universities and/or public research organisations (PROs). Most universities aim at providing a broad educational spectrum, which of course is the basis for research as well. Therefore, one would expect activities in all fields for all countries or regions disposing of universities. What can make the difference however, are PRO, which tend to be more focussed on a limited number technology and/or scientific fields. However, given the ongoing restructuring at universities and PROs, the broadness of the educational structure may diminish and strategic publishing may be rising which may lead in the longer run, to noticeable changes in the relative scientific specialisation profile.

At policy levels, scientific specialisation shows the positioning of a national research system in the world. At regional level, however, one may question the usefulness of such a positioning. First of all, at NUTS1 level, many regions are closer to the level of Luxembourg than to Belgium in terms of total publication figures, and thus, in many field they will be reported as being non-specialised. In case they obtain a positive specialisation, this again may be the wrong signal as the actual number behind this value are marginal compared to the world total.

While relative scientific specialisation may not be less useful at regional level, relative technological specialisation seems more promising as many EU regions are specialised in industries or technologies (such as ICT in Finland, the automobile industry in Baden-Wuerttemberg, Niedersachsen, Piemont, or Slovakia, the textile industry in the North-Eastern regions of Italy, the cross-border Öresund region, Sweden and Denmark in biomedicine). Technological specialisation provides a basis for the analysis of competitiveness, and with some further refinement can be analysed to study innovation potential and technological spill-overs.

III.1 Scientific specialisation

A territory (whether it be a country or a region) displays, generally speaking, a unique scientific profile, which is relatively stable over time. The profile is a mirror of its scientific expenditure priorities. If a country invests heavily in physics research, one can expect a larger number of scientific publications in physics; the output measure of scientific research. Only a few, most often, larger countries like the US have a wider presence in most scientific disciplines but even in such a 'complete' economy, divergence in outputs between fields can emerge over time.

At the other extreme, the smaller a country, the more distinctive is its measurable scientific profile. This fact can largely be attributed to limited financial as well as scientific human resources and the need for specialisation, in the sense of focussing on a limited number of fields. Scientific output comes largely from public institutions such as universities and PROs. The smaller a country, or region, the less likely it is that it will host major universities or PROs.

For very small economies like Malta, Luxembourg and Cyprus, which produce 50-150 publications on average annually, the analysis of the absolute numbers provides a picture of the fields in which scientists are publishing. However, it is difficult to speak about relative specialisation as the numbers are too insignificant to offer scope for a statistical analysis.

Since the publication numbers for the smallest EU Member States are statistically insignificant, the same can be said for many EU27 regions. Accordingly, Figure III-1a and III-1b present specialisation profiles for EU Member States to provide a first snapshot at the level where specialisation patterns are most relevant. Figure III-2 then examines the regional totals in order to examine where scientific publications originate within each country.

Methodological caveats

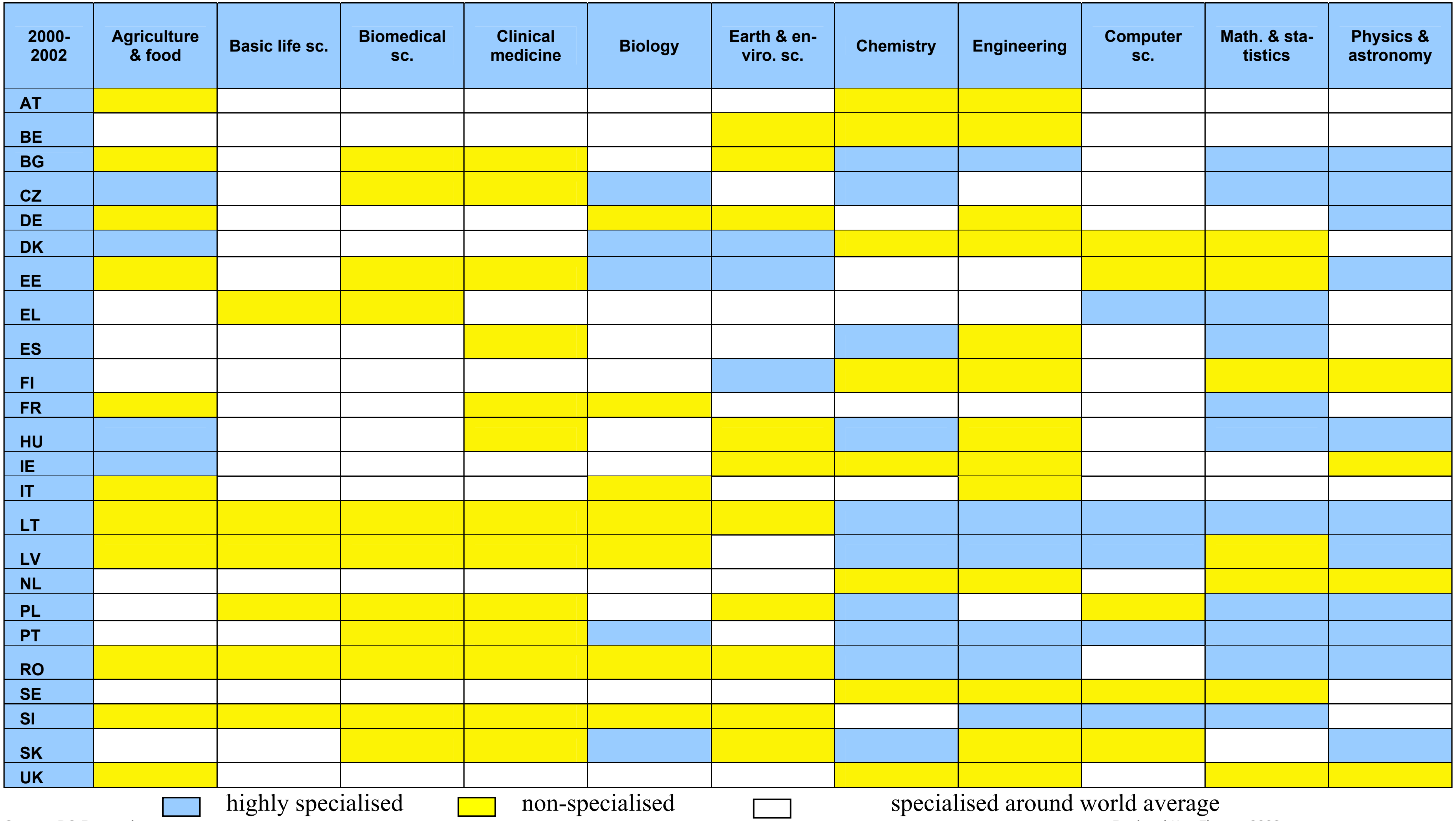
A major point to consider for the analysis of scientific output is the fact that the dataset has some internal biases such as language and scientific disciplines. The data tends to be dominated by English speaking journals and focuses in particular on the life sciences. Despite these caveats, the analysis of scientific publications is worthwhile and the method has proven its power in many studies. The Science Citation Index (SCI) provided by Thomson Scientific is the data source underpinning the current analysis. This database is of high quality, as the inclusion or exclusion of journals is decided on the 'journal impact factor', which is a measure of the average citations that publications in each journal receive. The data is also highly internationalised, both in terms of journals covered and authors represented in the journals. The SCI covers a broad coverage of technical and scientific fields, reflecting scientific development especially in natural sciences, medicine and engineering areas. However, there are some limitations in international comparability especially of some engineering fields, which play a larger role in the scientific system of many countries than is evident from this database. Furthermore, arts and humanities as well as social sciences are not included in the analyses, since the primary interest is in hard sciences.

Country level specialisation is relatively constant over time

Figures III-1a and III-1b show, for those EU Member States with sufficient publications, the specialisation patterns in 2000-2002 and 2003-2005. While during 2000-2002 the EU Member States had a positive specialisation (blue coloured cells) in 52 fields (19.7% of all fields), in 89 fields (yellow cells, 33.7%) they were not specialised. In the remaining 123 fields (white cells, 46.6%), scientific activities were close to the world average. A positive specialisation of the EU Member States is found most often in chemistry, physics, as well as mathematics and statistics. Negative specialisations are found generally in the life sciences such as basic life sciences, biomedical sciences and clinical medicine, but also in engineering.

What can be observed when the 2000-2002 period is compared to the 2003-2005 period? Certainly, there are more scientific fields showing a positive specialisation (82 or 31.1%), and less negative ones (60 or 22.7%). The scientific fields with an average score remain almost stable (122 fields or 46.2%). In terms of scientific disciplines, the shifts are marked across the board. However, for some like the basic life sciences and clinical medicine as well as computer sciences, the extent of positive change is quite impressive. At the same time, the positive specialisation in certain fields, such as chemistry, physics and mathematics, has not been lost. On the contrary, at least for physics and mathematics, it has even got stronger.

Figure III-1a Scientific specialisation at country level, 2000-2002

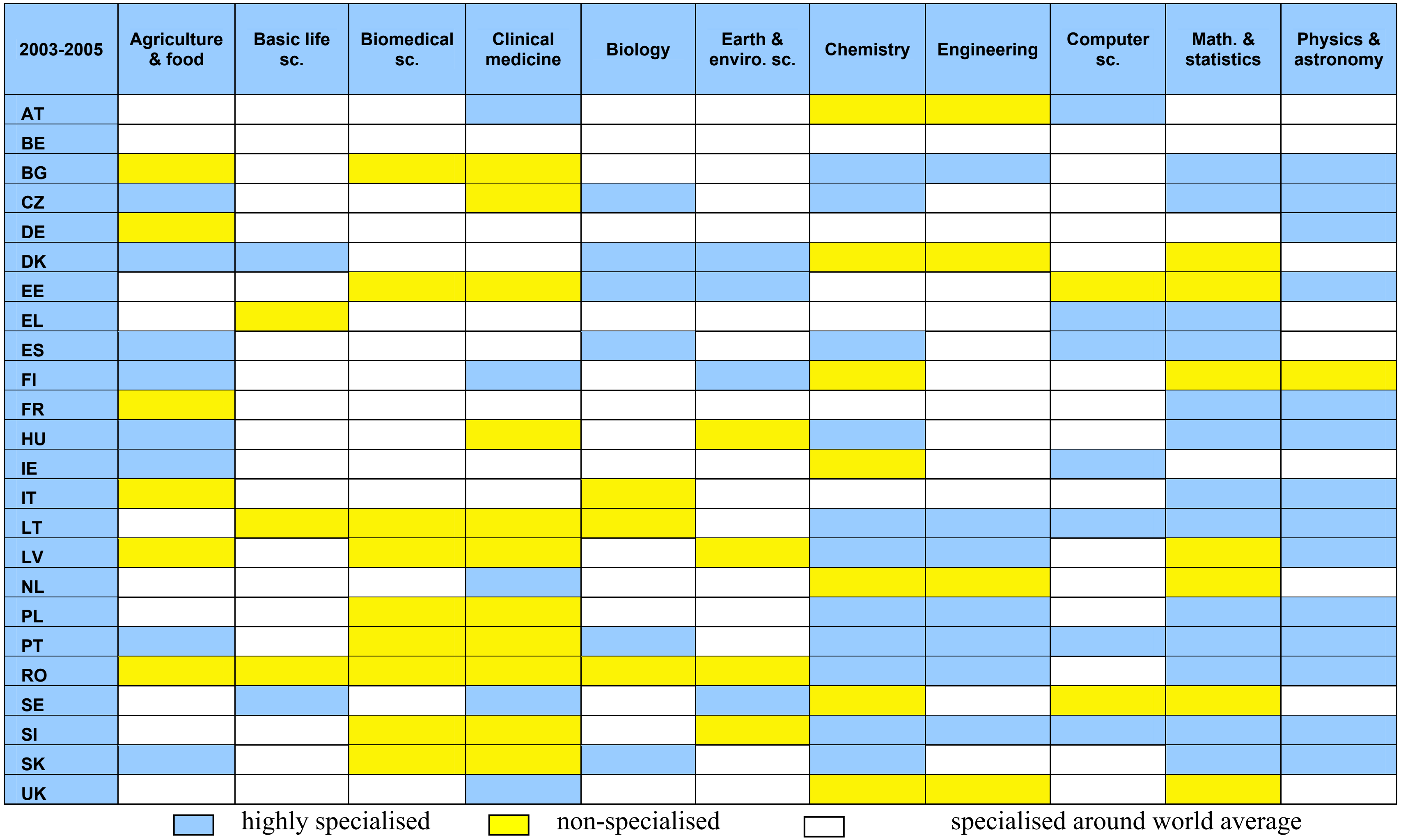


Source: DG Research

Data: Thomson Scientific / CWTS, Leiden University. Calculations: Technopolis

Regional Key Figures 2008

Figure III-1b Scientific specialisation at country level, 2003-2005



Source: DG Research
Data: Thomson Scientific / CWTS, Leiden University. Calculations: Technopolis

What do these changes signify and what could be the reasons for this increased specialisation? Given the fact that research disciplines and traditions do not change quickly from year to year, these changes are surprising. One obvious reason for the increased specialisation would have been an increase in the R&D labour force or increased funding; however significantly positive trends did not occur in either of these input indicators at the beginning of the century in the EU27. On the other hand, decreasing funding often leads to a concentration of research activities; and at the level of fields, a thematic concentration (mirroring a concentration of researchers and funding) will show not immediately, but in later periods with a specialisation matrix showing less positive specialisation and a higher share of non-specialisation fields. However, this was not yet the case in 2003-2005.

A second reason may be advanced: researchers were and still are increasingly encouraged to publish in international peer-reviewed journals (which are largely the basis for publication analysis as it is done here). Therefore, the absolute as well as relative publication shares of EU research rose. As the push to publish can be seen worldwide and the pool of peer-reviewed international journals covered for publication analysis remains about the same size, one may expect changing scientific specialisation profiles because Asian countries (in particular China) have increased their productivity and achieved tremendous growth rates which impact the EU27 and US scientific profiles significantly.

Regional scientific productivity

While it does not make much sense to look at the publication numbers by scientific field at the regional level, it is worth looking at scientific productivity and growth rates. Combined, these indicators enable an analysis of which regions produce a larger share of the national scientific output and which ones are catching up.

Table III-1 Top EU27 publishing regions 2005 and regions with highest growth rates (2002-2005)

Top publishing regions	Nr. of publ. 2005	Regions with highest growth rates	Growth 2000-2005
FR1 - Ile de Francce	24530	RO4 - Macroregiunea patru	165.93
SE0 - Sweden	21450	RO1 - Macroregiunea unu	74.24
NL3 - West-Nederland	19380	PT3 – Madeira	25.06
DEA - Nordrhein-Westfalen	18756	*MT0 – Malta*	20.43
UKI - London	18327	BG1 - Severna Bulgaria	18.63
DE1 - Baden-Wuertemberg	17130	*LT0 – Lietuva*	15.96
DE2 - Bayern	16336	*CY0 - Kypros/Kibris*	15.24
UKJ - South-East	14616	GR1 - Voreia Ellada	15.15
ES5 - Este	12812	PT1 - Continente	14.68
ITC - Nord-Ovest	11389	*LU0 - Luxembourg*	14.52
UKM - Scotland	10498	PL2 - Poludniowy	13.87
		GR2 – Kentriki Ellada	13.60
		ES4 - CENTRO (E)	13.27

Source: DG-Research Regional Key Figures 2008
Data: ISI-Thomson Scientific/ CWTS Leiden Univeristy; Data treatment: Technopolis
Notes: Countries (NUTS0) are marked in italics

In terms of absolute numbers on scientific articles, the numbers range from 24,500 in *Île de France* down to one in the Finnish *Åland*. The average number of publications across the 12 NUTS 0 and 83 NUTS 1 regions was 5,219 publications in 2005.

Looking at 2005 data in more detail, the 10 regions with the highest absolute publication rates come from seven countries (including Sweden at NUTS 0 level). Almost the same is true for the regions with the highest growth rates. However, among the leading ten regions are four small EU Member States (Table III-1). While this list is led by the French capital region with 24,000 publications, the bottom is made up largely of the regions with the highest growth rates: two Romanian regions (*Macroregiunea unu* and *Macroregiunea patru*), Latvia, Luxembourg, *Severna Bulgaria*, Malta, the Portuguese islands of *Azores* and *Madeira*, as well as the French Overseas Departments and the Finnish *Åland* islands, all produced within a range of one to 280 publications. There are only a few regions, which produced less than 100 publications per year: *Åland*, the French *Overseas Departments*, the *Azores* and *Madeira*, as well as *Malta*.

In terms of productivity of a given region, the publication figures are more telling if weighted by GDP or population. In Table III-2, the top regions with the highest per capita productivity are listed (again including Sweden at NUTS 0). The biggest jump can be seen for the region of Brussels. While in terms of absolute numbers it is only 54th out of 95 regions, when population is taken into account it is the most productive region in terms of scientific output.

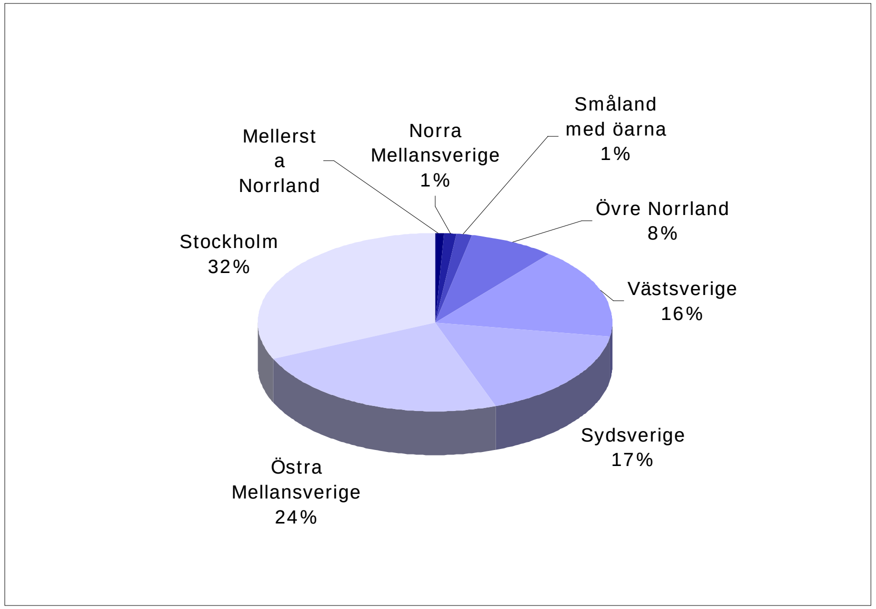
For a number of countries, it is possible to examine scientific productivity at a lower geographic level even if specialisation data is not available. Scientific publishing shares in Sweden, for example, can be examined at the level of the eight NUTS 2 regions. Doing so allows a more qualitative explanation of why certain regions account for higher shares (i.e. the location of significant universities, etc.).

Table III-2 Top European publishing regions 2005 per population (1)

	Number of publications per population
BE1 Région de Bruxelles/ Brussels	2.79
DE3 Berlin	2.59
NL3 West-Nederland	2.55
UKI London	2.47
SE Sweden	*2.38*
FR1 Ile de France	2.17
DE5 Bremen	2.13
UKM Scotland	2.07
DE6 Hamburg	2.01
UKH Eastern	1.83
UKJ South East	1.81

Source: DG-Research Regional Key Figures 2008
Data: ISI-Thomson Scientific/ CWTS Leiden Univeristy; Data treatment: Technopolis
Notes:(1) per 1 000 inhabitants. Countries (NUTS0) are marked in italics.

Figure III-2 Publication shares in Swedish NUTS 2 regions, 2000-2005



Source: DG-Research Regional Key Figures 2008
Data: ISI-Thomson Scientific/ CWTS Leiden Univeristy;
Data treatment: Technopolis

Between 2000 and 2005, the Swedish annual 'production' of scientific literature rose from 16,000 to 21,000 (a total of 114,000 publications over six years). Regional divergence in the contribution to these totals is evident from figure III-3: *Stockholm* counts for a third of Swedish scientific production, *Östra Mellansverige*, which includes university towns such as *Uppsala* and *Örebro*, with 24%, *Sydsverige* (*Lund, Mälmo*) with 17% and *Västsverige* (university city of *Göteborg*) with 16% follow. The other regions account for only a minor share of between 1 to 8%.

In terms of growth rates, the highest regional rates at EU level can be found in two Romanian regions, which during 2000 and 2003 had barely a single publication. However, in 2004 and 2005 a significant number of publications led to growth rates of 165% in *Macroregiunea patru* and 74% in *Macroregiunea unu*. In absolute terms these two regions produced respectively 130 and 270 publications in 2005.

Other regions which come from a low base but obtain about 10 to 20% average annual growth and had a total publication number of more than 100 in 2005 can be found in many countries: Bulgaria's Severna region, *Voreia Ellada* in Greece, Portugal's *Continente*, Poland's *Poludniowy* or Germany's *Brandenburg*, to name but a few.

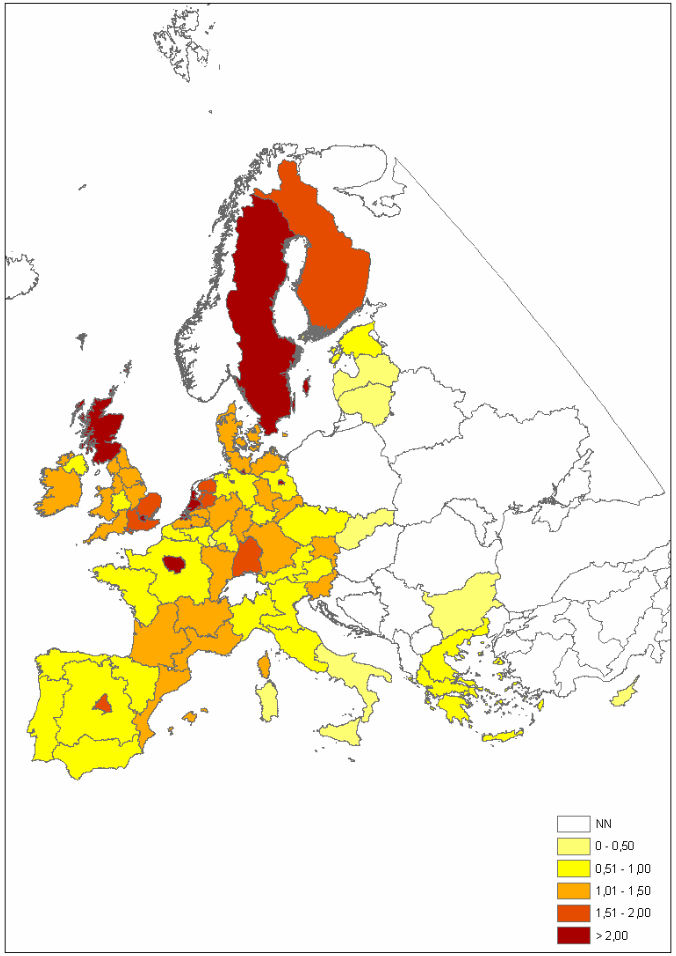
Regional scientific intensities: 'a dynamic Y' of top regions

While it is difficult to appraise the scientific specialisation of regions, they can at least be analysed in terms of productivity. Figure III-2 shows NUTS 0 and NUTS 1 regions' publication intensities. The darker the colouring, the higher is the intensity. These darker coloured regions form a distorted 'Y', starting in Scotland, traced down to Catalunya and up over Bavaria to Finland.

In terms of intensities, Figure III-3 clearly shows that geographic centrality is not the dominant factor for scientific activity. It can be speculated that it matters more to be connected: scientific co-publications which are on the rise for a number of years as well as the need to publish in international journals in order to be recognised, can be taken as reasons why small, non-English speaking and/or 'peripheral' regions do rather well. Another factor is certainly the knowledge stock: the number of researchers in universities and research institutions have an impact, which cannot be measured with the existing data here[17].

In short, scientific specialisation and productivity at regional level appear to be more influenced by the location of major academic centres and the top performing regions are more geographically dispersed than the "blue banana" of regions described in the previous chapter where R&D expenditure (notably business) is concentrated.

Figure III-3 Publication intensities (1) in European regions, 2005



Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Publications or patents Calculations: Fraunhofer ISI
Notes: (1) per 1 000 inhabitants

[17] Please see the bibliometric analysis in the Third European Report on S&T indicators. (EC 2003). Large universities and research centers, scored better in terms of publication intensity as well as impact factors for many scientific fields than medium-sized ones. On the other hands, specialised ones did very well in their field of specialisation.

III.2 Technological specialisation

Methodological remarks

Patents provide a vested right for the exclusive usage of a certain technology. On the one hand, they represent one important output measure of research. On the other hand, patents are a potential input for further technological development processes and eventually commercial products or services generating value added. They are therefore a tool to assess the potential future technological strengths and competitiveness of companies, regions or countries.

The exclusive right is only valid in the territory of a certain patent office. For example, a granted patent of the French patent office (INPI) has no effect in Germany. If a patent protection is also needed in Germany, an additional application to the German patent office (DPMA) is mandatory. Several procedures exist which simplify the application procedures, if protection is requested in more than one country, and one of them is the application to the European Patent Office (EPO), which is a filing and a granting institution. However, at the end of the procedure at the EPO there are still national patents – in as many countries as the applicant wants to obtain patent protection and is willing to pay the annual fees. A 'Community Patent', valid in all EU countries, does not exist. Furthermore, the EPO is not an EU institution. On the contrary, many of the member states of the EPC, which is the underlying convention of the EPO, are not members of the EU and vice versa.

For the analysis presented here, patent applications at the EPO are examined. European patent filings are preferred to, for example, so-called triadic patents or filings to the US Patent Office (USPTO). Methodological reasons (timeliness and comparability) as well as the importance of the European market for companies located in the EU region warrants this approach.

Applications are used instead of granted patents as applications reflect the results of research processes and can be used as an output measure. Furthermore, several reasons than just formal ones exist that lead to abandoning the granting process so that only a fraction of all possible technological innovations represented by patent indicators are covered by granted patents. The years of the patents are assigned based on the priority date, the date of the worldwide first application of the technology, which is the closest available year to the date of invention. Patents are assigned to countries or regions based on the inventor's address rather than the address of the applicants as it is more interesting to identify where the knowledge was produced instead of the ownership of the legal right. Total patent filings as well as those for 'high-technology' patents are used. The latter are often considered especially interesting in term of innovation; since they represent promising technological areas in terms of future market potential and competitiveness.

Different countries and regions have different propensities to patent not only because of their size, their research orientation and the degree of internationalisation of companies, but also because of differing propensities of different technological fields to be patented. For example, patentability in the area of chemistry or pharmaceuticals is rather high, while the number of patents in relation to R&D expenditure is lower in mechanical engineering or the automobile sector. To overcome these size and propensity effects and to make technological fields as well as countries and regions comparable, specialisation indices as well as patent intensities (application per 1 million inhabitants) are used.

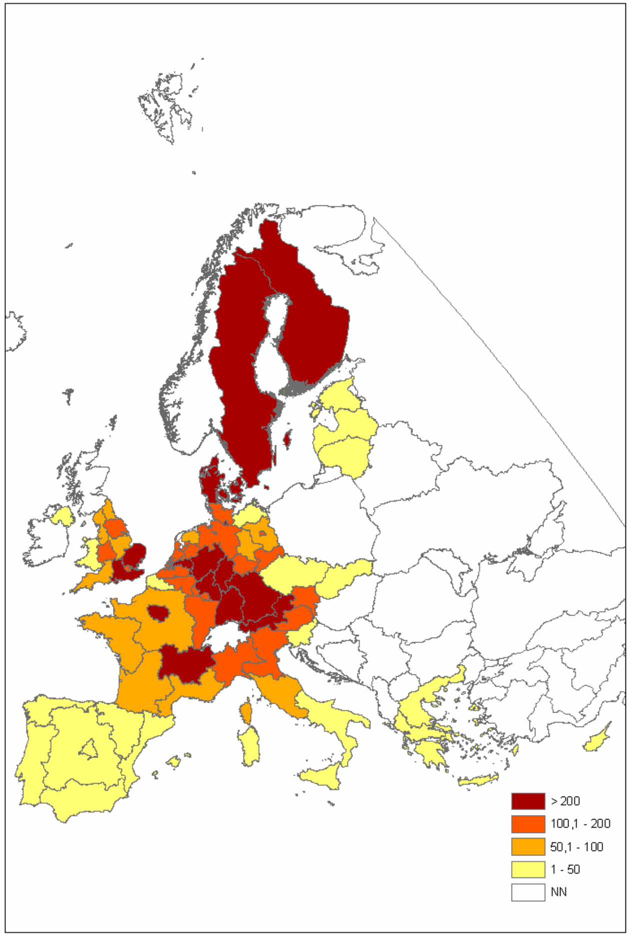
III.2.1 Patent analysis at NUTS 0 and NUTS 1 level

Patent statistics reveal a heterogeneous picture of Europe

The countries with the highest number of patent applications in the EU27 are also the largest countries in terms of population. German inventors applied for about 23.000 patents at the EPO in 2001 followed by France (~8.000), the UK (~6,000), Italy and the Netherlands (both about 4.000). Moreover, US inventors represented the largest group at the EPO with about 32.000 patent applications while Japanese inventors apply for about 20.000 patents at the EPO per year. However, the absolute number of patent filings only tells a small part of the story. Relative strength and relative competitiveness is more telling in terms of potential innovation performance. Small countries like Sweden or Finland are successful because they have gained comparative advantages in several technological areas; and they are specialised in certain fields.

Looking at the breakdown of patent filings by region reveals heterogeneous patent activities within Europe (Figure III-4). The southern part of the Netherlands (*Zuid-Nederland*) is the region with the highest patent intensity, applying for more than 800 patents per 1 million inhabitants in 2001. Sweden, mainland Finland (*Manner-Suomi*), Denmark, *western Austria*, *South-East* and *East* England and the *Île de France* are in the top group. Most parts of Germany display high patent intensities, with the southern regions leading and the eastern regions lagging behind, but still reaching a level that is above the EU average. The peripheral regions in Spain, Italy, Greece and the Baltic States form the group of regions with the lowest patent intensities in the EU.

Figure III-4 Patent intensities (1) in European regions, 2001



Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI
Notes: (1) per 1 000 000 inhabitants

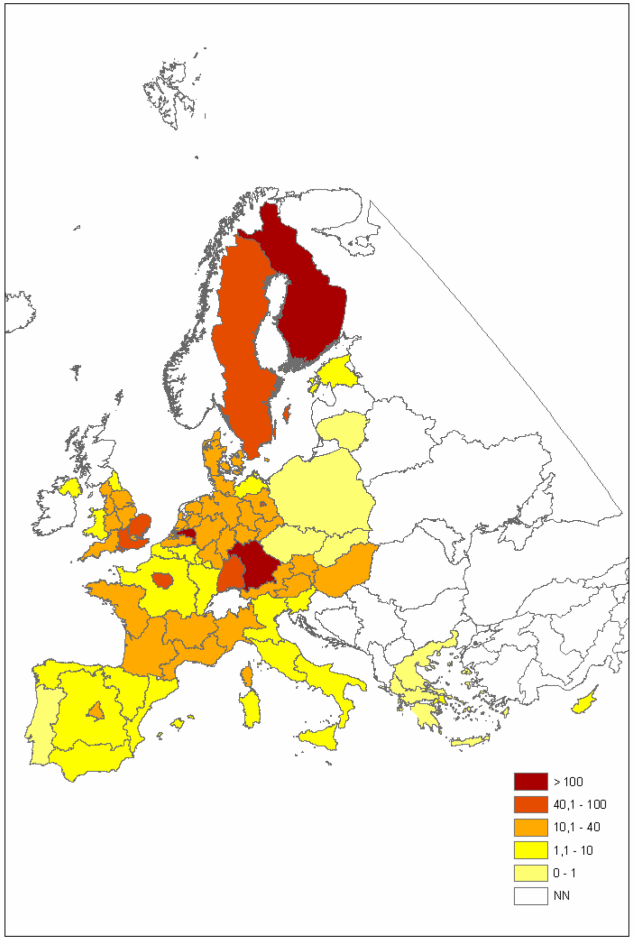
Only a few regions are currently active in high-tech areas

The analysis of high-tech patents (Figure III-5) reveals a slightly different picture. *Zuid-Nederland* is still at the top of EU regions applying for about 370 high-tech patents at the EPO per one million inhabitants in 2001. Furthermore, Sweden and the *Bayern* region are in the top group, followed by a group consisting of *East of England, Île de France, Baden-Württemberg, South East UK* and *Berlin*. Some of the other actively patenting regions following in the next group, indicating that the total number of patent filings of these regions is focused on low or medium technological sectors.

Germany for example, is not specialised in high-tech at country level, but focuses on medium-high technology areas like mechanical engineering or automobiles. Leading edge technologies like information and communication technologies (ICT), biotechnology or pharmaceuticals is only prominent in certain German regions.

In contrast, Sweden and Finland are much more focused on ICT and related technologies so that their total patent output is dominated by these technologies. The eastern EU Member States as well as Portugal and Greece show very low levels of high-tech patenting. The *Kostep* region in Hungary is a positive exception, reaching a position close to the EU average. Most parts of Spain, northern France and most regions in Italy are also not very active in high-tech patenting. This is on the one hand based on their low total number of patents, but especially in the cases of northern Italy and northern France, a considerable orientation towards low and medium tech is evident. **High-tech patenting is concentrated in Scandinavia, the southern Netherlands, south east England and Southern Germany**.

Figure III-5 High-Tech Patent intensities (per 1 000 000 inhabitants) in European regions, 2001



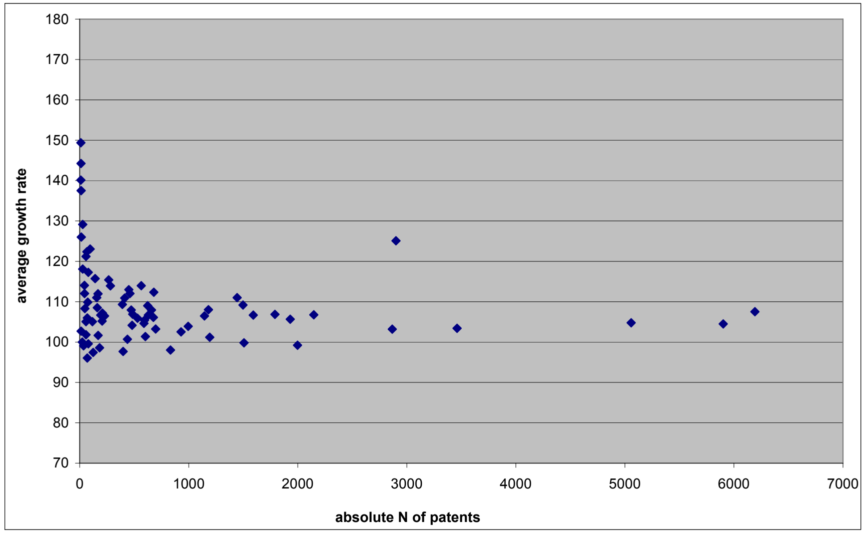
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

High-Tech patents show a more dynamic development across all regions than total patent filings

To grasp the underlying dynamics and the overall trends on a regional level, figures III-6 and III-7 display the absolute numbers of patent filings and the average growth rate since 1998 for the NUTS 1 regions. Two main conclusions can be drawn.

First, as can be seen on the horizontal axis, the distribution of absolute numbers of both total filings and high-tech patents, is rather heterogeneous. For high-tech patenting a larger gap between the top regions (*Zuid Nederland and Bayern*) and followers is visible than in the case of total patent filings.

Figure III-6 Patent specialisation profile of EU27, 2001-2003

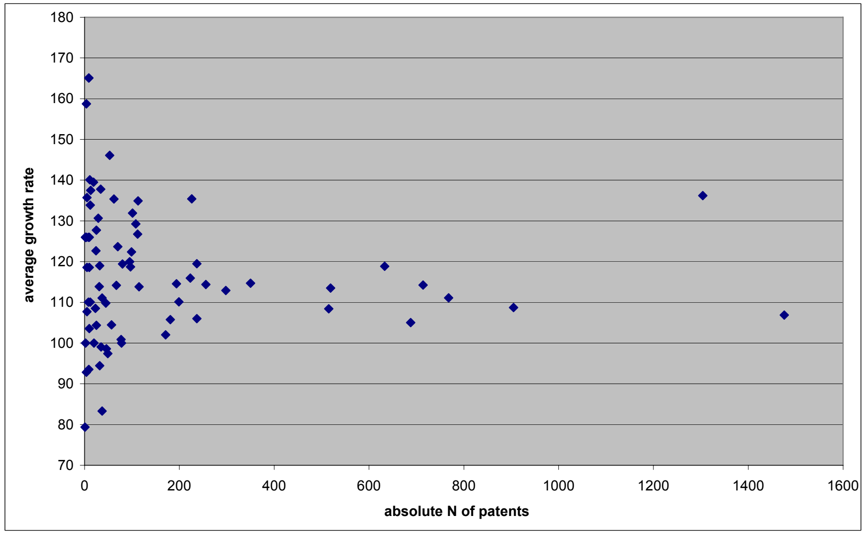


Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Furthermore, the regions achieving a medium level are also more limited in the case of high-tech patents, resulting in a crowding at the bottom.

Second, the growth rates are much more scattered in the case of high-tech patents compared to all patents. On the one hand, many more regions are growing faster in terms of high-tech patents than the general trend would suggest. This can be derived from the vertical axis. On the other hand, there are also more regions showing a negative trend, indicating shrinking absolute numbers of high-tech patent filings. The reason might be that the high-tech regions suffered especially from the economic downturn and a reduction, postponement or, in some cases, a slowdown of R&D processes.

Figure III-7 High-tech patent specialisation profile of EU27, 2001-2003



Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Generally speaking, high-tech patents are growing faster than the total patent filings at the EPO, which indicates a shift of many regions towards a more R&D-intensive technological output. The *Zuid-Nederland* region shows not only a high absolute number of patents but also a high average annual growth rate of about 36% for 1998-2001. Only a few regions reach higher growth rates, but none of them has a comparable absolute number of filings. Among the growing regions with a considerable absolute number of high-tech patents are *southern Austria, south and east Spain, Kozep in Hungary and the west of France*.

Does technological specialisation lead to a comparative advantage?

The absolute number of patent applications of countries and regions not only depends on research investment, human capital or the network effects between universities, research institutes, small and medium-sized enterprises and large companies, but also on the technological orientation and the technological structure. Different propensities to patent and different degrees of patentability add to differences in absolute numbers. These differences are crucial and help explain specialisation.

Specialisation is one factor driving economic growth, implying that a given region focuses on a small number of technologies and that between regions, these technologies vary to a large extent; although some competition and some similarity is necessary for motivation, cooperation or intellectual exchange. Indeed, an efficient division of labour as well as a bundling and integration of competences, skills and strengths is at the core of the ERA.

For a better assessment of comparative advantage, the specialisation index enables to distinguish the performance of regions or countries beyond size effects. A positive value of the index reflects activities in a certain field that are above the world average, meaning that a region or country is more engaged in a certain technology than could be expected based on its weight. Logically, negative values represent a specialisation that is below the world average.

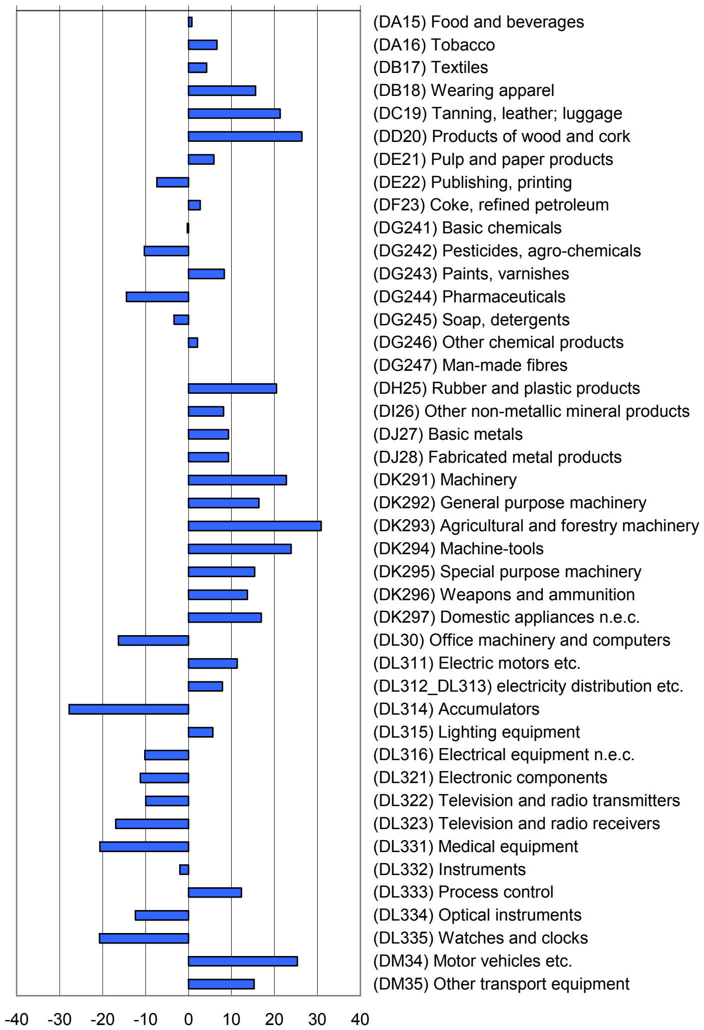
As can be seen from figure III-8, the EU27 countries in total are specialised in certain consumer goods like paper products, apparel (textiles) or wood products. A broad specialisation is visible in metal products and especially in all kinds of machinery. Positive specialisation indices also exist in office machinery and computers, electricity distribution and lighting. On the other hand, sectors such as electronics as well as medical equipment or instruments do not contribute positively to the EU's specialisation profile, showing even negative values in this index.

In some of the sectors, the EU has lost its comparative advantage to other parts of the world where the income level is lower, for example in television and radio devices. For the EU's technological profile, transportation (including railway equipment, ships as well as cars, lorries and trailers) plays the most important role in absolute as well as in relative terms.

Indeed, the specialisation indices of the EU27 do not display extreme values. The reason is being that total worldwide activities (which are the denominator in the calculation of this index) are heavily influenced by the sum of the EU27 Member States.

A similar absence of extremes can be observed for the USA, the largest and most important national market for technologies and high-tech products. However, the US profile can be characterised as "complementary", showing strength and weaknesses that are mostly opposite to the EU27 patenting activities.

Figure III-8 Patent specialisation profile of EU27, 2001-2003



Source: DG Research
Data: EPO patent applications. Calculations: Fraunhofer ISI

For example, the US is strong in high-tech areas like ICT and especially in life sciences (pharmaceuticals, biotechnology, medical equipment and instruments) where the EU27 is comparatively weak.

A positive specialisation in high-tech areas does not automatically imply higher rates of growth (valued added or productivity), For instance, between 1995 and 2005, the role of services sectors in EU growth was substantial and among manufacturing, only two sectors (electrical and optical equipment and chemicals) can be highlighted[18],

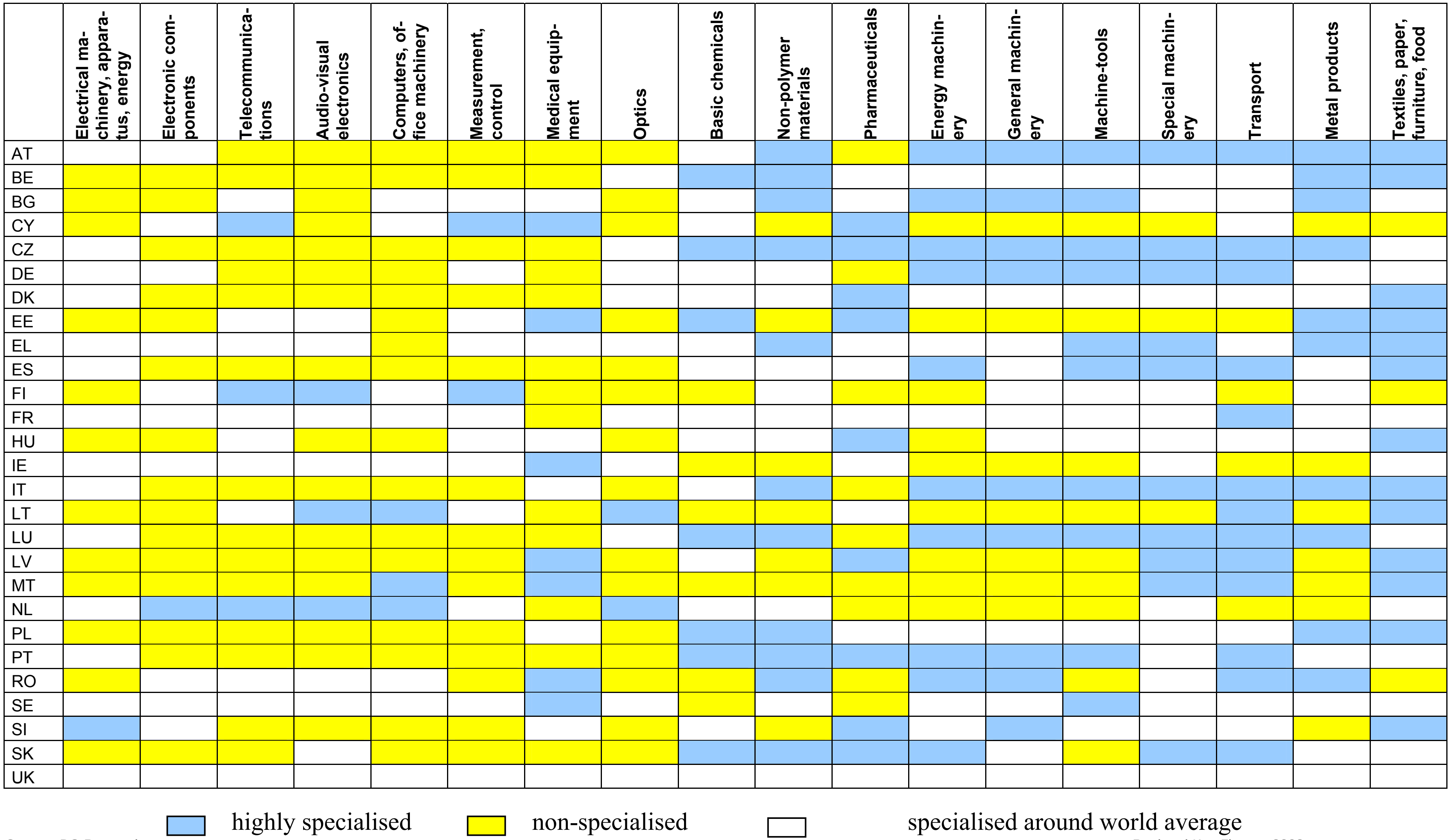
Evidence on the factors driving growth does suggest that the sectoral composition of an economy towards more or less high-tech sectors has an influence on growth rates, however this is only one amongst a range of factors (others include macroeconomic conditions, demand-side factors, market structure, openness and barriers to trade)[19]. Hence, there is a need to be cautious in linking specialisation patterns to economic performance of a country or a region[20].

Nevertheless, a positive specialisation in low-tech sectors such as agricultural products, textiles, pulp and paper is unlikely to have as strong a leverage effect on value added as a positive specialisation in pharmaceuticals, medical equipment or ICTs. In particular, all the industries with the highest rates of value added growth in the European Union – communication equipment, office machinery and computers, as well as telecommunications and computer related services – relate to ICT.

Figure III-9 provides an insight into specialisation by country, for the period 2001-2003: positive specialisation indices above a value of 20 (blue cells) occur mostly in the mechanical engineering and transport sectors. For the electronics and ICT sectors, most countries have a negative specialisation (yellow cells, below a value of -20); or (average specialisation (white cells).

While the EU27 picture is broadly uniform, there are significant 'outliers': the Netherlands and Finland, notably, have positive specialisation indices in ICT. Sweden was specialised in this sector from the second half of the 1990s, but fell back to average by 2000; although in the telecommunications sector, the values remain positive. Smaller countries like Cyprus, Lithuania or Slovakia reach positive values in some electronics sectors, but the low absolute numbers of patents prevents a general and sustainable impact on the overall profile. France and Ireland reach average values in most of these areas. The UK is the only country with roughly average specialisation indices in all technological fields. The UK used to have a positive specialisation in pharmaceuticals and positive values in some areas of ICT. However, these were the fields that suffered most in the recession in the period 2000.

Figure III-9 Technological specialisation at country level, 2001-2003



Source: DG Research
Data: EPO patent applications. Calculations: Fraunhofer ISI

Regional Key Figures 2008

III.2.2 Technological specialisation in selected NUTS 2 regions

The previous chapter has illustrated that there is a heterogeneity at NUTS0 and NUTS1 level. However, the degree of heterogeneity is even higher at NUTS2 level. The most significant difference in this level is due to size: the largest NUTS2 region is the *Île de France* (FR10) with more than 11 million inhabitants, whereas the smallest regions have less than 300,000 inhabitants. This implies further differences in their technological output. The technological specialisation of a given region depends on the absolute number of patents (the input to the equation calculating the index). Hence, low numbers of patents lead to inconsistent and volatile results that are difficult to interpret. Therefore, the analysis in this chapter focuses only on the 100 largest NUTS2 regions[21] in terms of absolute patent applications within the EU27[22].

The heterogeneity of regional performance is also reflected in the absolute numbers of patents, as can be seen in Table III-1. The *Ile de France,* congruent with the results at NUTS1 level, is the largest patent filing region, followed by *Sweden, Stuttgart, and Oberbayern*. The fifth region on this list is *Noord-Brabant*, which applied for about 3,000 patents less than the *Île de France* in the period 2001-2003. The smallest regions among the 100 largest patent applicants have less than 300 patents in three years; or about 3% of the number of patents applied for by the *Île de France*. This difference is not only explained by size effects in terms of population or employment figures, but it can be derived from patent intensities, i.e., the number of patents per 1 million employed.

In relative terms, *Noord-Brabant* is the most patent-intensive region within Europe, filing more than 2,200 patents per million employees in three years. There is of course an obvious reason for this intensity: the region is home to the electronics giant Philips. Applying relative intensities, the *Île de France* falls back to rank number 20 on this list which shows that there is a scale effect which needs to be taken into account. *Stuttgart* and *Oberbayern* are able to maintain their good position. Other German regions move up the list, reaching intensities of more than 1,000 patents. A re-shuffling of ranks also occurs in the middle (*Catalunya*, *Noord-Holland* and *outer London*) and at the lower end of the list, which is closed by *Lazio, Aquitaine, Közép-Magyarország, and Madrid*. Hence, it is necessary to look beyond absolute numbers. In order to arrive at a complete picture and to allow for a comprehensive assessment of a region's technological strengths and weaknesses, relative figures are more relevant.

21 Including those NUTS2 regions, which are identical at a different level such as the Ile de France (NUTS1 equals NUTS2) or Sweden, and Denmark (where data is only available at NUTS0).

22 Moreover, the analysis uses a three year time period (2001-2003) in order to minimise volatility and to have a statistically relevant and sufficient number of patents.

Table III-1 Number of patent applications to the EPO, patent intensities and growth index for top 100 regions at NUTS2 level, 2001-2003

	Absolute N of patents (2001-2003)	Intensities (per 1 Mio. employmen	Growth index (1995=100)
FR10 - Île de France	8501	678	148.7
SE - Sweden	8049	669	153.1
DE11 - Stuttgart	7382	1587	202.0
DE21 - Oberbayern	7275	1480	191.6
NL41 - Noord-Brabant	5708	2211	409.3
DEA2 - Köln	4042	868	158.8
ITC4 - Lombardia	3995	386	167.0
DEA1 - Düsseldorf	3950	730	137.6
DE71 - Darmstadt	3891	888	121.8
DE12 - Karlsruhe	3703	1154	189.5
FR71 - Rhône-Alpes	3658	604	150.6
DK - Denmark	3642	437	178.8
FI18 - Etelä-Suomi	2535	897	201.3
DE13 - Freiburg	2531	928	166.2
DE14 - Tübingen	2301	1032	212.2
UKH1 - East Anglia	2275	959	209.2
DEB3 - Rheinhessen-Pfalz	2258	982	117.0
DE25 - Mittelfranken	2230	1091	189.2
UKJ1 - Berkshire, Bucks and Oxfordshire	2187	823	177.7
ITD5 - Emilia-Romagna	1974	420	185.7
DEA5 - Arnsberg	1944	489	165.7
DE30 - Berlin	1731	462	162.5
UKI1 - Inner London	1582	514	210.3
ITD3 - Veneto	1521	288	178.3
DE27 - Schwaben	1475	628	173.4
ITC1 - Piemonte	1419	287	142.9
DEA3 - Münster	1344	497	164.5
DE92 - Hannover	1309	578	191.0
DE26 - Unterfranken	1307	866	181.2
FR82 - Provence-Alpes-Côte d'Azur	1268	323	171.8
DEA4 - Detmold	1251	583	212.4
NL33 - Zuid-Holland	1245	282	133.3
DEF0 - Schleswig-Holstein	1143	383	210.2
UKI2 - Outer London	1130	231	127.7
ES51 - Cataluña	1124	154	227.2
DE91 - Braunschweig	1122	621	269.8
UKJ3 - Hampshire and Isle of Wight	1087	477	164.5
FI19 - Länsi-Suomi	1067	774	216.4
DE23 - Oberpfalz	1059	812	217.3
DE60 - Hamburg	1017	508	190.7
FR52 - Bretagne	972	296	286.0
UKJ2 - Surrey, East and West Sussex	892	284	133.3
UKG1 - Herefordshire, Worcestershire and Warks	858	522	145.2
NL32 - Noord-Holland	813	226	154.1
FR42 - Alsace	799	390	182.4
AT13 - Wien	774	358	190.2
DED2 - Dresden	772	451	286.7
BE21 - Prov. Antwerpen	771	405	98.2
DE94 - Weser-Ems	746	267	200.7
FR62 - Midi-Pyrénées	739	278	154.3
AT31 - Oberösterreich	725	436	162.4
UKD3 - Greater Manchester	708	233	124.9
UKH3 - Essex	699	385	157.3
ITE1 - Toscana	693	180	208.8
UKF1 - Derbyshire and Nottinghamshire	687	303	151.9

Absolute Intensi- Growth
N of patents (2001-2003) ties (per 1 Mio. em-ploymen index (1995=100)
Absolute N of Intensi-ties Growth index

	patents (2001-2003)	(per 1 Mio. em-ploymen	(1995=1 00)
DEG0 - Thüringen	683	249	263.4
DE24 - Oberfranken	681	506	159.3
DEB1 - Koblenz	678	404	154.7
DE72 - Gießen	670	570	142.6
NL22 - Gelderland	661	269	131.5
DE93 - Lüneburg	659	357	168.4
FR24 - Centre	635	243	127.8
UKG3 - West Midlands	620	237	136.7
ITE4 - Lazio	615	128	147.6
UKK1 - Gloucestershire, Wiltshire and Bristol/Bath area	594	220	180.7
AT22 - Steiermark	593	396	191.9
FR51 - Pays de la Loire	556	182	171.2
UKJ4 - Kent	554	300	150.0
ES30 - Comunidad de Madrid	552	96	207.3
NL42 - Limburg (NL)	546	412	158.9
UKE4 - West Yorkshire	537	233	144.2
BE24 - Prov. Vlaams Brabant	530	464	135.9
NO01 - Oslo og Akershus	528	390	180.9
AT12 - Niederösterreich	522	278	166.7
DE22 - Niederbayern	513	391	185.8
FR23 - Haute-Normandie	497	258	138.3
NL31 - Utrecht	492	322	181.7
FR30 - Nord - Pas-de-Calais	469	136	131.3
BE23 - Prov. Oost-Vlaanderen	453	260	193.7
UKD5 - Merseyside	450	317	131.3
DEC0 - Saarland	449	386	165.7
FR41 - Lorraine	428	162	145.9
FR81 - Languedoc-Roussillon	395	211	140.9
FR61 - Aquitaine	391	124	117.6
FR22 - Picardie	385	214	155.3
	Absolute N of patents	Intensi-ties (per 1	Growth index (1995=1

	(2001-2003)	Mio. em-ploymen t)	00)
FR26 - Bourgogne	384	255	122.2
FR43 - Franche-Comté	380	254	131.3
FI1A - Pohjois-Suomi	374	619	161.0
FR72 - Auvergne	373	339	256.9
DE73 - Kassel	358	279	143.4
DE42 - Brandenburg - Südwest	347	154	246.2
UKF2 - Leicestershire, Rutland & Northants	346	160	133.7
BE10 - Bruxelles/Brussel	341	488	174.0
AT34 - Vorarlberg	341	843	215.4
HU10 - Közép-Magyarország	333	120	195.8
BE25 - Prov. West-Vlaanderen	320	261	169.4
BE33 - Prov. Liège	319	387	229.0
NL21 - Overijssel	311	277	145.5
BE31 - Prov. Brabant Wallon	301	930	183.3
NO04 - Agder og Rogaland	275	412	204.8

Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Another perspective can be provided using growth indices, in order to try to capture trends since the mid 1990s by comparing the number of patent filings in 2001 with those in 1995. However, at the NUTS2 level it has to be taken into account that regions focusing on leading-edge technologies like ICT and biotech suffered more from the economic downswing after 2000 than others. Referring to the growth index, *Noord-Brabant* shows an impressive growth with four times more patents in 2001 than in 1995; followed by *Dresden*, *Bretagne, Braunschweig and Thüringen*. Interestingly, regions like *Catalunya*, which was at the lower end in terms of intensities, are among the most dynamic regions in Europe. Although all regions show a positive development over time, except for *Antwerpen*, the growth rate of some regions is far below the total trend at the EPO. This is the case for the *Île de France* although it needs to be taken into account that it is the more difficult to maintain high growth rates in larger regions. Nevertheless, there are also smaller regions that recorded below average growth rates such as *Bourgogne, Darmstadt, Aquitaine and Rheinhessen-Pfalz*.

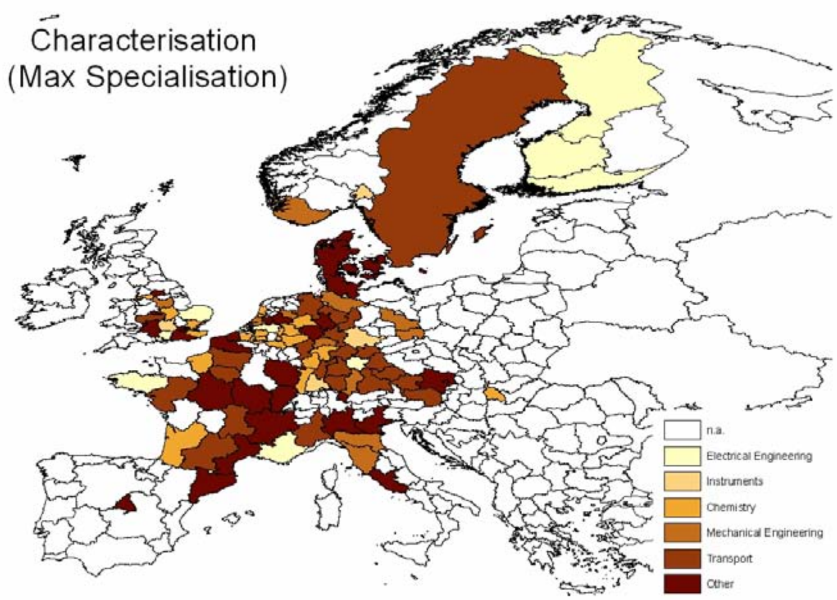
Focus of technological specialisation favours central and northern Europe

As can be seen from the map in Figure III-10, the top 100 regions in terms of patent activities are mainly located in central and northern Europe, especially Germany, the southern UK, northern Italy and parts of France. The specialisation index is calculated as the share of patents in a specific technology within a region in relation to this technology's patent share worldwide. Positive values indicate activities that are above the worldwide average, negative values point to activities that are below the average, respectively. A first approach to the analysis of the specialisation at NUTS2 level is the field of maximum specialisation indices in the 100 regions.

Many regions in Germany, the *Île de France*, and Sweden as well as some selected regions in Italy (*Piemont*), the UK (*Hertfordshire*) and Austria (*Oberösterreich*) are specialised in transport (including automobiles, trains and aeronautics). Electrical engineering is an outstanding strength in *Noord-Brabant*, some parts of Finland, in the South East UK (*East Anglia and Hampshire*), parts of France (*Provence and Bretagne*) and Germany (*Berlin and Mittelfranken*).

The focal point in chemistry (including chemistry, pharmaceuticals and biotechnology) lies in western Germany (*Düsseldorf, Köln*, *Darmstadt, Rheinhessen-Pfalz, Münster), Essex, Alsace and Noord-Holland*. Mechanical engineering, interestingly, is only the top specialisation of four regions, two of which are in Germany (*Schwaben and Dresden*), one in Italy (*Emilia-Romagna*) and one in the Netherlands (*Zuid-Holland*).

Figure III-10 Characterisation of top 100 regions at NUTS2 level by field of maximum specialisation, 2001-2003

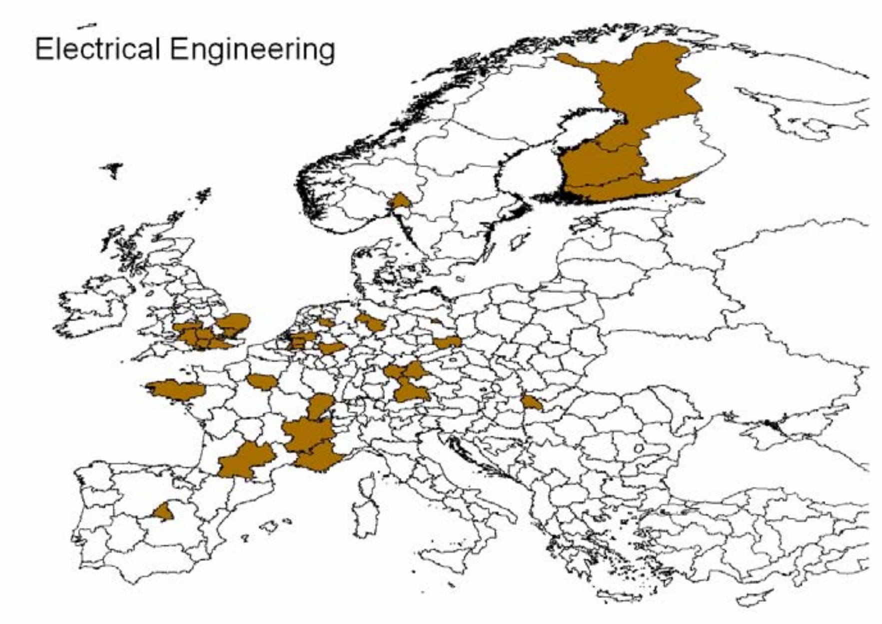


Source: DG Research
Data: EPO patent applications. Calculations: Fraunhofer ISI

Regional Key Figures 2008

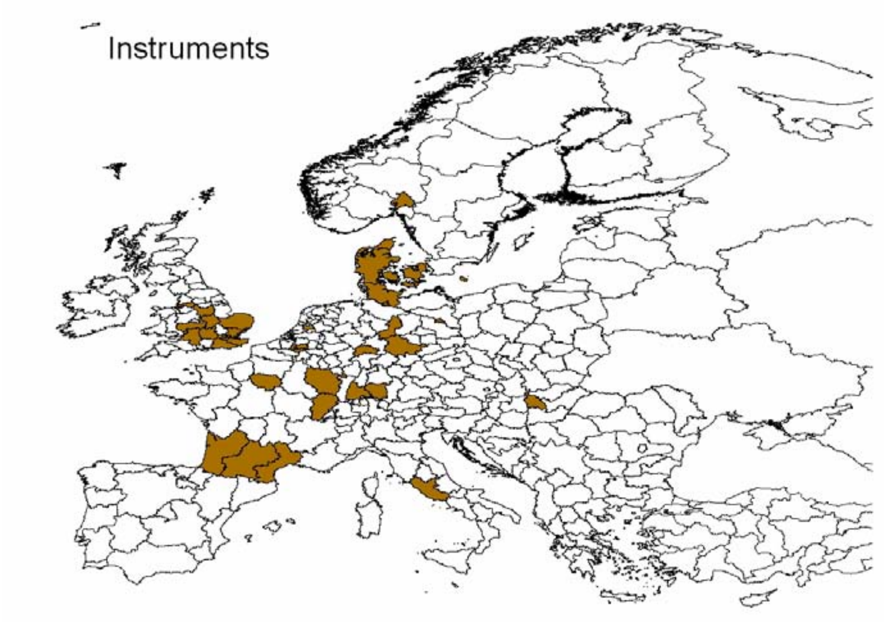
The maps in Figures III-11 to III-17 provide information on positive specialisation in each of the technological areas; displaying only positive specialisation above the value of 20. Electrical engineering is strong in a third of the 100 regions examined. The Finnish *Pohjois-Suomi* and Dutch *Noord-Brabant* are the only two regions with a positive specialisation in electrical engineering. All other regions being examined have at least two or more positive values, indicating a slightly broader specialisation.

Figure III-11 Specialisation of top 100 regions at NUTS2 level in Electrical Engineering, 2001-2003



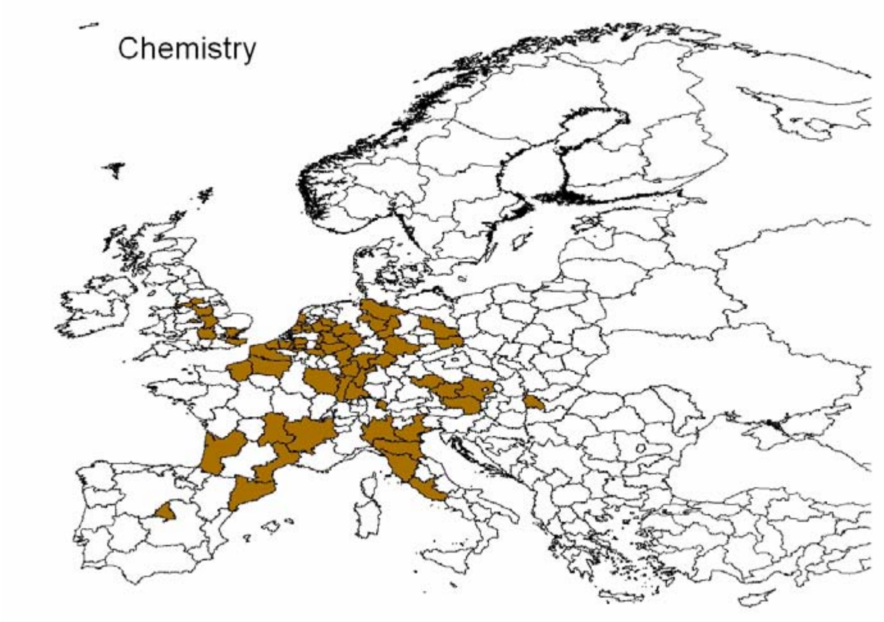
Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Figure III-12 Specialisation of top 100 regions at NUTS2 level in Instruments, 2001-2003



Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

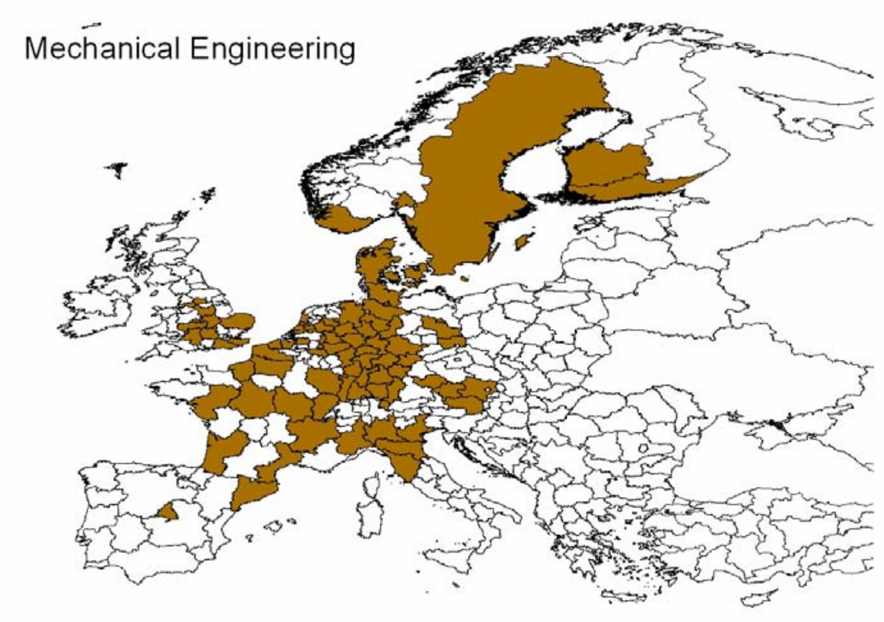
Figure III-13 Specialisation of top 100 regions at NUTS2 level in Chemistry, 2001-2003



Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

The chemical industry is concentrated in Germany, France, and Italy. Some regions in England, Belgium, the Netherlands, Spain, Poland and Hungary are equally positively specialised.

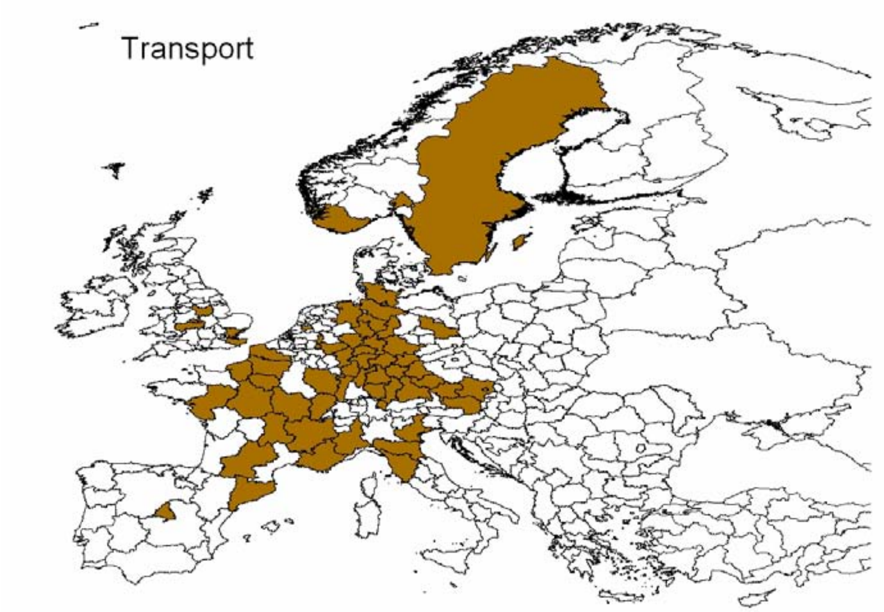
Figure III-14 Specialisation of top 100 regions at NUTS2 level in Mechanical Engineering, 2001-2003



Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Mechanical engineering competences are by far the most basic and common activities of the top 100 regions active in technology production. Another striking results is that chemistry positively contributes to the technological profile of a large number of regions, especially in Germany (19 regions), the UK (10), France (9), the Netherlands (6), and Italy (5) and the Belgian regions. On the other hand, while only 12 regions have their highest specialisation in mechanical engineering, 81 regions have a significant positive specialisation in this field.

Figure III-15 Specialisation of top 100 regions at NUTS2 level in Transport, 2001-2003

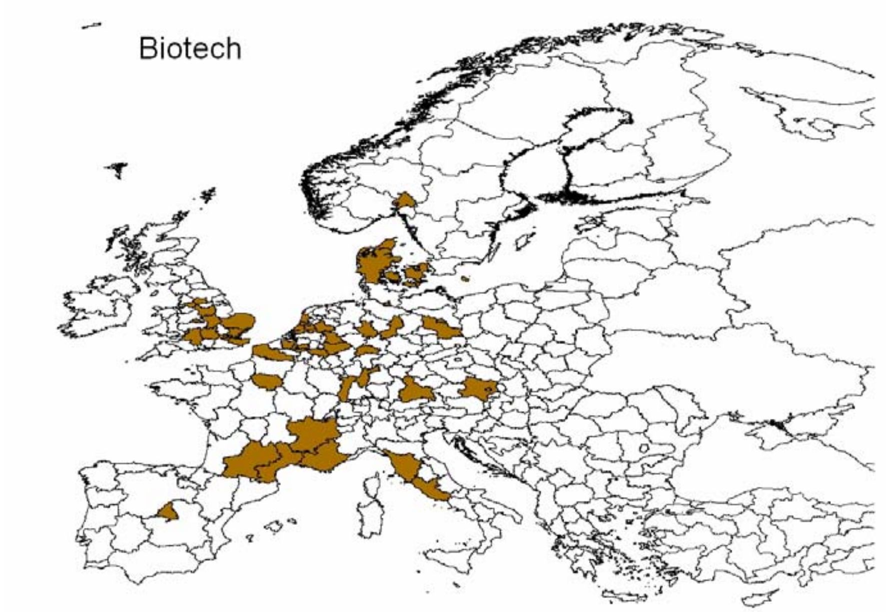


Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Transport is a field where most German regions reach outstanding positive values on the specialisation index as well as regions in France, Austria, Italy and Spain.

To further differentiate the technological profile of some regions in selected modern, applied technologies, the maps in Figures III-13 and III-14 present positive specialisation values in biotechnology (analysed above in the chemistry field) and ICT, respectively.

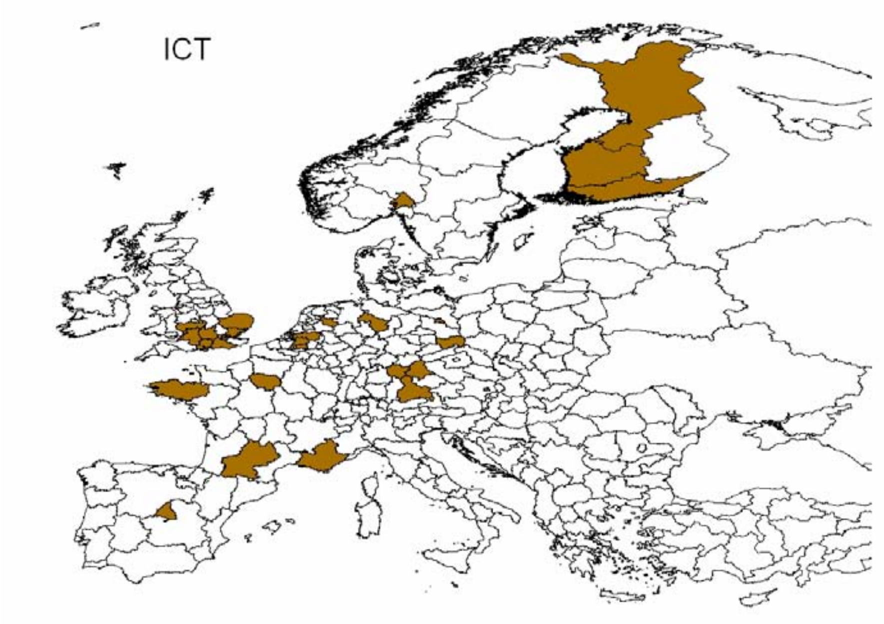
Figure III-16 Specialisation of top 100 regions at NUTS2 level in Biotechnology, 2001-2003



Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Biotechnology research is concentrated in the larger countries (Germany, France and the UK) as well as in Belgium, the Netherlands and Denmark. Obviously, this research-intensive technology is most successfully implemented by countries/regions, which have some considerable activity and a reasonable strength in chemistry and/or pharmaceuticals, so that the diversification into biotechnology is a logical consequence of existing activities.

Figure III-17 Specialisation of top 100 regions at NUTS2 level in Information and Communication technologies (ICT), 2001-2003

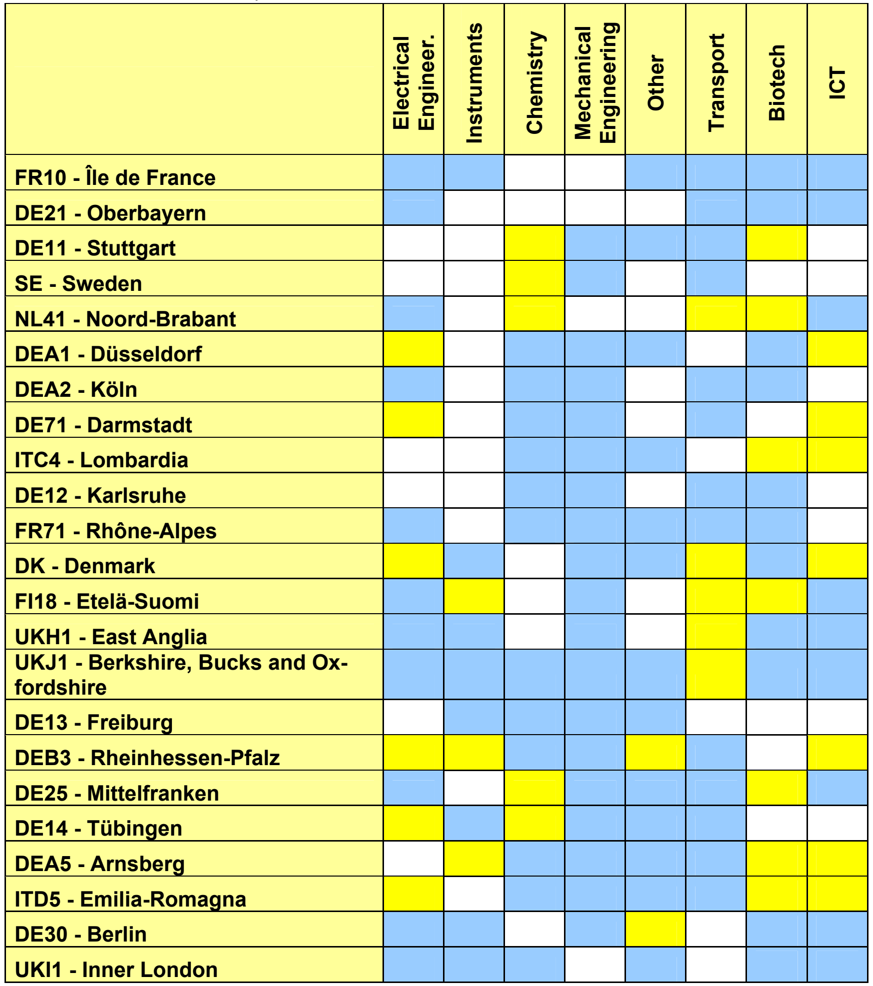


Only values of the specialisation index >20 are displayed.
Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI

Looking at ICT specialisation profiles, a parallel with the positive specialisation in electrical engineering is evident. This points to the fact that most of the patents in electrical engineering are in ICT, and, effectively, in regions which have some experience in traditional electrical engineering. ICT make a positive contribution to the technological profile in many regions of the UK, in Finland, in France, some parts of southern and eastern Germany, and again the Noord-Brabant, which stands out.

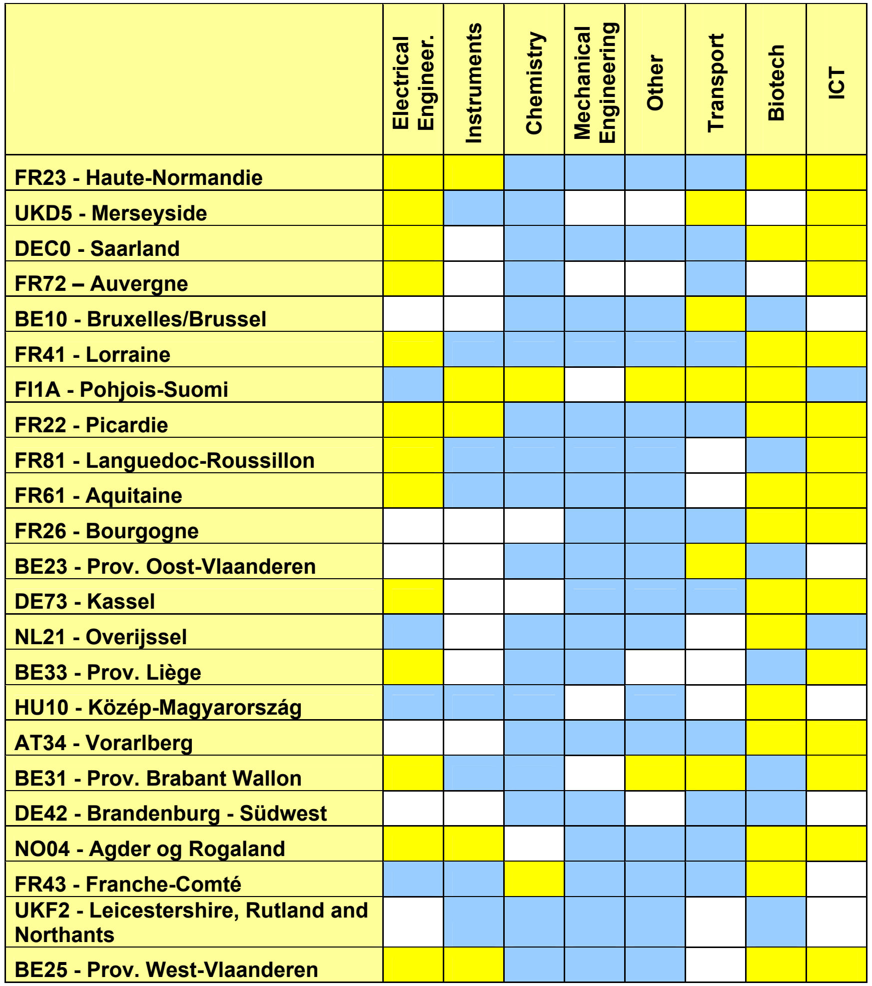
Figure III-18 summarises the positive and negative specialisation in the 100 regions in all eight technological fields under examination.

Figure III-18 Technological specialisation for top 100 regions at NUTS2 level, 2001-2003



	Electrical Engineer.	Instruments	Chemistry	Mechanical Engineering	Other	Transport	Biotech	ICT
ITD3 - Veneto								
DEA3 - Münster								
DE92 - Hannover								
DE26 - Unterfranken								
DEA4 - Detmold								
DE27 - Schwaben								
ITC1 - Piemonte								
FR82 - Provence-Alpes-Côte d'Azur								
UKI2 - Outer London								
NL33 - Zuid-Holland								
DEF0 - Schleswig-Holstein								
FI19 - Länsi-Suomi								
ES51 - Cataluña								
DE91 - Braunschweig								
UKJ3 - Hampshire & Isle of Wight								
DE23 - Oberpfalz								
DE60 - Hamburg								
FR52 - Bretagne								
UKJ2 - Surrey, East and West Sussex								
DED2 - Dresden								
UKG1 - Herefordshire, Worcestershire and Warks								
UKH3 - Essex								
FR42 - Alsace								
NL32 - Noord-Holland								
FR62 - Midi-Pyrénées								
AT31 - Oberösterreich								
DE94 - Weser-Ems								

	Electrical Engineer.	Instruments	Chemistry	Mechanical Engineering	Other	Transport	Biotech	ICT
UKF1 - Derbyshire & Nottinghamshire								
BE21 - Prov. Antwerpen								
AT13 - Wien								
DE72 - Gießen								
UKD3 - Greater Manchester								
DEG0 - Thüringen								
DE93 - Lüneburg								
NL22 - Gelderland								
DEB1 - Koblenz								
ITE1 - Toscana								
DE24 - Oberfranken								
UKG3 - West Midlands								
ITE4 - Lazio								
FR24 - Centre								
UKK1 - Gloucestershire, Wiltshire and Bristol/Bath area								
UKJ4 - Kent								
ES30 - Comunidad de Madrid								
FR51 - Pays de la Loire								
UKE4 - West Yorkshire								
NL42 - Limburg (NL)								
DE22 - Niederbayern								
AT22 - Steiermark								
NO01 - Oslo og Akershus								
BE24 - Prov. Vlaams Brabant								
AT12 - Niederösterreich								
FR30 - Nord - Pas-de-Calais								
NL31 - Utrecht								



Source: DG Research Regional Key Figures 2008
Data: EPO patent applications. Calculations: Fraunhofer ISI
Notes: yellow signifies an under-specialisation whereas blue signifies a positive specialisation. The white boxes show patent activity around world average.

IV. Key findings and implications for regional research policy

This booklet has delved into the topic of a relative scientific and technological specialisation at regional level in the EU27. It provides a first broad brush approach to an issue which merits further analysis and study. The importance of first considering the structural indicators for R&D intensity is clearly to provide pointers as to where we might expect to see increased or decreasing specialisation over time.

A persistent regional concentration of R&D performance

There are a number of regions, which in terms of the structural indicators such as R&D intensity or high-tech employment are always in the upper or lower ranks. The group of regions with the highest R&D intensity in the EU27 (i.e. GERD above 2% of GDP) is also the one with the highest growth of this indicator over time (2000-2005). On the other hand, the regions with lower intensities often registered a relative decrease in R&D spending.

It is noteworthy that the top regions also score higher in terms of shares of GERD performed by the business sector (BERD) whereas government sector plays much stronger role in the regions with lower R&D intensity.

The exceptions among the least R&D intensive regions (i.e. GERD below 1% of GDP) are several regions in Spain and Hungary where R&D intensity increased in the analysed period. It has to be kept in mind, however, that these regions are growing from a relatively low level and have a low share of R&D performed by business.

Table IV-1 and IV-2 provide the "top-" and the "bottom-" 10 performing regions[23] for the selected indicators presented in the previous chapters. In both cases, only a limited number of regions are present. Table IV-1 presents the top 10 regions and includes a total of 22 regions. Two regions are included six times (*East of England and Île de France*), followed by four regions, which are present in five of the six indicators (*Baden-Württemberg, Bayern, Manner-Suomi and UK South-East*); *Berlin* is in the top 10 for four indicators, *Bremen, Hessen and Zuid-Nederland* are included three times; while *Brussels, London and Centre-Est France* are included twice; nine other regions are in the top-10 for only one indicator. Looking at these 22 regions, they are geographically located in the aforementioned European "Blue Banana".

Not surprisingly, a number of city-regions are highly successful. They are often the capital cities such as Madrid, London, Paris, Brussels or Berlin. Other regions, such as West-Nederland, which host the capital, or city-states such as Bremen and Hamburg, equally perform well.

Concerning the regions lagging behind, a total of 23 regions are included in the list of six indicators. Two regions are included five times, *Dunántúl (HU) and Wschodni (PL)*, and two regions are included four times, *Åland (SE) and Acores (PT)*; while nine regions are included three times, five regions twice and another five regions are included once. Several of the laggard regions are (often remote) islands, with a small population: *Åland, the Azores, Madeira, Ca-*

[23] The tables do not include NUTS0 regions and those for which data is unreliable.

nary islands and the French overseas departments are all population-wise small, and relatively remote. Looking at the publication figures, it is clear that these island regions lack major academic institutions generating graduates to undertake research. It is unlikely that there will be much change in terms of R&D intensity over time, since even if additional public resources are channelled to conduct R&D in these regions, the difficulty of attracting sufficient critical mass in terms of people or business R&D investment will remain.

Hence, this study confirms that in general the geography of R&D intensity displays a strong centre-periphery pattern being persistent over time and difficult to reverse. As pointed out there are a number of cleavages persistent on the R&D intensity map: European core (or "Blue Banana") versus European periphery as well as metropolitan areas and rural areas, notably in the new Member States.

Revealed patterns of scientific and technological specialisation

In terms of scientific productivity (based on absolute number of publications), the analysis revealed that most of the top publishing regions belong to the European core. However, the highest growth rates in publications (10-20% annual growth) appear in the EU27 periphery (e.g. regions in Romania, Portugal, Bulgaria, etc.), which seem to be starting to catch-up, however, from a very low level. Importantly, a closer look at data suggests that scientific specialisation and productivity at the regional level is more influenced by the presence of major universities than geographical centrality. As would be expected, a good relative performance in scientific output in the regions outside the "Blue Banana" coincides with the presence of a university or a major public research centre.

Technological specialisation measured using patent applications (EPO). A glance at the NUTS1 level patenting map reveals an interesting geographical pattern with a very strong concentration of patenting activity in the European core (e.g. Zuid-Netherland, Western Austria, South-East of England, Bayern, Baden-Wurttemberg. Ile de France) and Nordic countries (e.g. Manner-Suomi. Denmark). This is not far from the pattern observed in analysis of regional R&D intensity.

The picture changes into an image resembling "Islands of Innovation"[24], when the analysis focuses on high-tech patents. Here the most intensive regions include Zuid-Nederland, Bayern, Baden-Wurttemberg, Ile de France, Southern Swedish regions, South-East of England, and Berlin. A positive example of an "emerging island" on the high-tech patenting map is Kostep in Hungary. In general, however, regions in southern and eastern EU Member States have very low levels of high-tech patenting. Interestingly, high-tech patenting activity displays more dynamic developments than total patenting and tends to grow faster then total patent filings at the EPO. A notable finding in this context is that there are fast growing regions in high-tech patenting outside the European core (e.g. east Spain, and the aforementioned Kozep in Hungary), which suggests that the geography of "Islands of Innovation" may be applicable to the R&D specialisation patterns.

Analysis of regional technological specialisation on the NUTS2 level reveals even greater heterogeneity on the European map. Nevertheless, the general geographical pattern is preserved with the NUTS2 regions located in the central and northern EU Member States performing best.

24 The islands of innovation concept was first proposed in the study by "Archipelago Europe: islands of innovation", (Hilpert, U. 1992, Synthesis Report Brussels, Commission of the European Communities (DG XII; MONITOR/FAST).

The maps focussing on selected technology fields strongly resemble the “islands of innovation” pattern with most specialised NUTS2 regions displaying different spatial patterns depending on the technology in focus. Often, several NUTS2 regions cluster together forming a sort of “mega-islands of innovation” as e.g. well-known Oresund region between Denmark and Sweden specialised in biotech and instruments, South-East French regions specialised in chemistry or Finish regions active in ICT.

The “Islands of Innovation” pattern is more pronounced in areas of biotech, electrical engineering, instruments and ICT. In the areas of chemistry and, particularly, mechanical engineering and transport, the specialisation seem to be less geographically fragmented spilling over to the larger connected central and northern European core. Comparison of various fields indicated parallel patterns between related technological areas as e.g. ICT and electrical engineering.

Implications for the regional research policy

What can be said about the majority of regions, which are neither the 'star-performers' or are faced with specific geographic or historical obstacles? Many of these regions are now on both a national, and international, scale beginning to compete for R&D investments and promoting their main cities, notably those with universities or large research infrastructures, as "hot-spots" where it is attractive for knowledge workers (or what Richard Florida has called the ‘creative classes’) to come and live; or where national policy-makers should be investing their funds (for example, the French “pôle de compétitivité", technology clusters programme which required regions to bid in to receive funds to strengthen internationally competitive clusters of scientific and technological activity).

Clearly being able to show that a region or city is specialised in one or more technologies is often a force of attraction, an internationally reputable physics department, the R&D facility of a major multinational firm, etc. are all "magnets" for skilled people seeking challenging jobs; or for businesses seeking to locate R&D facilities. The agglomeration or clustering effects written about in academic studies are visible in scientific and research activities in many regions across Europe.

In this context, the regions that seem to be under-performing are the geographically relatively centrally located regions of Poland, Romania and Hungary. They cannot 'blame' geographical remoteness for their situation but rather due to historical economic and socio-political reasons have not maintained adequate science producing infrastructures or retained business sectors investing intensively in R&D. In this context, R&D policy intervention may be able to influence trends here over several decades, but again this is unlikely to make much difference to economic growth rapidly.

The difficulty is to align 'city-marketing' type information, which can be relatively precise about the number of top researchers at the local university in such-or-such a field and the number of top-level publications they have produced; with the 'macro-data" available if the aim is to compare specialisation at regional level across the EU27. A top-performing institute in a specific larger region will only influence at the margins the specialisation patterns or trends. Even if it was possible to obtain data, and meaningful to analyse it, at a NUTS3 level (the city or district level), would the conclusions to be drawn be of use from a policy point of view?

Would knowing that there are 40 top NUTS3 city-districts in terms of R&D intensity or that 20 NUTS3 'regions' are specialised in biotechnology influence choices of policy makers about where, for instance, to spend national or EU funds in this field? And if it did, would it really be a rational way to distribute funds? A mapping of scientific or technological specialisation patterns does not in itself constitute a sufficient basis for policy decisions. However, it does indicate where resources and activity are concentrated currently in specific fields. Hence, it may be used as one indicator, of a larger set of criteria, for making decisions about future investments where the objective is to build on existing infrastructure and capacity or to link together such ‘regional nodes’ in the European Research Area.

Further research

This booklet painted a general map of regional R&D specialisation in the EU. Given the methodological and data limitations, the patterns of specialisation shift “out of focus” when an attempt is made to zoom in to levels from NUTS2 and below. The booklet does, nevertheless, identify a number of policy relevant research problems, which could benefit from further analysis.

Selected issues include:

- analysing and mapping absolute scientific and technological specialisation of the EU regions in order to give a more solid basis to interpreting the relative specialisation analysis performed in the current booklet;

- an in-depth analysis of determinants and effects of the revealed differences in the dynamics of general and high-tech patenting activities;

- performing a number of case studies of the fast growing regions in terms of patenting activity, in particular high-tech patents, located outside European core;

- adding a dimension of innovation activity to scientific and technological specialisation findings on the regional level and comparing the revealed patterns;

- an inquiry into emerging geographical patterns in different technology areas to identify and compare “hot spots” of interdisciplinary R&D activity (regions emerging as specialised in many related technologies);

- an inquiry into what constitutes a “hinterland” of the technological “hot spot”, including an investigation of the regional collaborations between a top region and other regions (connectivity); given limited access or simply lack of data (e.g. high-tech trade) on the regional level a case study approach would be recommended.

Table IV-1 Top 10 performing regions in selected indicators

R&D intensity, 2005 (1)		GERD, in €m per 1000 inhabitants, 2005 (2)		BERD, 2005 or latest available year, €m PPS2000 (3)		Share of High Tech employment in total employment 2006		Publications per population 2005		High-tech patents per population 2001	
DE1 - Baden-Württemberg	4,19	FR1 - Île de France	1,277	DE1 - Baden-Württemberg	9319,4	FR1 - Île de France	8.6	BE1 - Region Bruxelles/ Brussels	2.79	NL4 - Zuid-Nederland	369.8
DE3 - Berlin	3,82	DE1 - Baden-Württemberg	1,275	DE2 - Bayern	7819,5	HU1 - Kozep-Magyarorszag	8.31	DE3 Berlin	2.59	FI1 - Manner-Suomi	148.9
FI1 - Manner-Suomi	3,5	FI1 - Manner-Suomi	1,048	DE7 - Hessen	3600,0	UKJ - South East	7.98	NL3 - West-Nederland	2.55	DE2 - Bayern	120.2
UKH - Eastern	3,42	DE5 - Bremen	0,973	DEA - Nordrhein-Westfalen	4568,8	DE1 - Baden- Württemberg	6.81	UKI - London	2.47	UKH - East of England	96.1
FR1 - Île de France	3,11	DE2 - Bayern	0,932	FI1 - Manner-Suomi	3226,1	FI1 - Manner-Suomi	6.67	FR1 - Île de France	2.17	FR1 - Île de France	81.4
DE2 - Bayern	2,91	DE3 - Berlin	0,890	FR1 - Île de France	8386,4	DE7 - Hessen	6.57	DE5 - Bremen	2.13	DE1 - Baden-Württemberg	67.6
AT2 - Südösterreich	2,91	UKH - Eastern	0,849	FR7 - Centre-Est	2766,5	ES3 - Comunidad de Madrid	6.53	UKM- Scotland	2.07	UKJ - South East	64.2
NL4 - Zuid-Nederland	2,77	DE7 - Hessen	0,835	ITC - Nord Ovest	3958,7	UKH - East of England	6.37	DE6 - Hamburg	2.01	DE3 - Berlin	57.3
DE5 - Bremen	2,62	NL4 - Zuid-Nederland	0,835	UKH - Eastern	3976,4	DE2 - Bayern	6.15	UKH - East of England	1.83	UKI - London	47.8
FR6 - Sud-Ouest	2,6	UKJ - South East	0,746	UKJ - South East	3792,9	BE1 - Region Bruxelles/ Brussels	6.1	UKJ - South East	1.81	FR7 - Centre-Est	42.1

Source: DG Research

Regional Key Figures 2008

Data: Eurostat, EPO, Thomson-Scientific (CWTS). Calculations: Technopolis Group and Fraunhofer ISI
Notes: (1) FR, AT, UK: 2004
(2) FR, AT: 2004, UK: 1999
(3) FR, AT: 2004

Table IV-2 Least 10 performing regions in selected indicators

R&D intensity, 2005 (1)		GERD, in €m per 1000 inhabitants, 2005 (2)		BERD, 2005 or latest available year, €m PPS2000 (3)		Share of High Tech employment in total employment 2006		Publications per population 2005		High-tech patents per population 2001	
GR2 - Kentriki Ellada	0,4	PT2 - Açores (PT)	0,047	BG4 - Yugozapadna i yuzhna centralna	50,4	ES1 - Noroeste	2.24	HU2 - Dunantul	0.23	ES7 - Canarias	0.6
HU2 - Dunántúl	0,39	PL6 - Pólnocny	0,021	ES7 - Canarias	48,3	ES7 - Canarias	2.03	RO2 - Macroregiunea doi	0.12	FR9 - French overseas departments	0.5
PL5 - Poludniowo-Zachodni	0,38	PL5 - Poludniowo-Zachodni	0,024	HU2 - Dunántúl	42,9	ES6 - Sur	2.01	PT3 - Madeira	0.21	HU2 - Dunantul	0.5
PT2 - Região Autónoma dos Açores (PT)	0,37	PL4 - Pólnocno-Zachodni	0,022	GR1 - Voreia Ellada	42,6	ES4 - Centro (E)	1.83	PL3 - Wschodni	0.21	PL2 - Poludniowy	0.4
PL6 - Pólnocny	0,36	PL3 - Wschodni	0,014	GR2 - Kentriki Ellada	34,6	RO4 - Macroregiunea patru	1.74	PT2 - Região Autónoma dos Acores	0.20	PL5 - Poludniowo-Zachodni	0.4
PL4 - Pólnocno-Zachodni	0,35	PL2 - Poludniowy	0,037	GR4 - Nisia Aigaiou, Kriti	8,8	PL3 - Wschodni	1.53	RO3 - Macroregiunea trei	0.08	GR1 - Voreia Ellada	0.2
PL3 - Wschodni	0,3	HU3 - Alföld és Észak	0,037	BG3 - Severna i iztochna Bulgaria	8,1	RO1 - Macroregiunea unu	1.47	RO1 - Macroregiunea unu	0.05	PL3 - Wschodni	0.2
PT3 - Madeira	0,28	HU2 - Dunántúl	0,030	PT3 - Região Autónoma da Madeira	1,8	GR1 - Voreia Ellada	1.27	FI2 - Åland	0.04	PL4 - Polocno-Zachodni	0.1
FI2 - Åland	0,14	BG4 - Yugozapadna i yuzhna centralna	0,026	FI2 - Åland	0,5	GR2 - Kentriki Ellada	1.18	RO4 - Macroregiunea patru	0.03	PL6 - Polocny	0.1
BG3 - Severna i iztochna	0,12	BG3 - Severna i iztochna	0,003	PT2 - Açores	0,2	GR4 - Nisia Aigaiou, Kriti	1.07	FR9 - French overseas departments	0.02	FI2 - Åland	0.0

Source: DG Research
Regional Key Figures 2008
Data: Eurostat, EPO, Thomson-Scientific (CWTS). Calculations: Technopolis Group and Fraunhofer ISI
Notes: (1) FR, AT, UK: 2004
(2) FR, AT: 2004, UK: 1999
(3) FR, AT: 2004

Annex I

Table A1 The 85 NUTS 1 regions and 12 NUTS 0 = NUTS 1 country-regions

BE	BE1 - RÉGION DE BRUXELLES-CAPITALE/ BRUSSELS HOOFDSTEDELIJK GEWEST		DE7 – HESSEN	**ES**	ES1 – NOROESTE
	BE2 - VLAAMS GEWEST		DE8 - MECKLENBURG-VORPOMMERN		ES2 – NORESTE
	BE3 - RÉGION WALLONNE		DE9 – NIEDERSACHSEN		ES3 - COMUNIDAD DE MADRID
BG	BG1 - SEVERNA BULGARIA		DEA - NORDRHEIN-WESTFALEN		ES4 - CENTRO (E)
	BG2 - YUZHNA BULGARIA		DEB - RHEINLAND-PFALZ		ES5 – ESTE
	BG3 - SEVERNA I IZTOCHNA BULGARIA		DEC – SAARLAND		ES6 – SUR
	BG4 - YUGOZAPADNA I YUZHNA CENTRALNA BULGARIA		DED – SACHSEN		ES7 - CANARIAS
CZ	CZ0 - CESKA REPUBLIKA		DEE - SACHSEN-ANHALT	**FR**	FR1 - ÎLE DE FRANCE
DK	DK0 - DANMARK		DEF - SCHLESWIG-HOLSTEIN		FR2 - BASSIN PARISIEN
DE	DE1 - BADEN-WÜRTTEMBERG		DEG – THÜRINGEN		FR3 - NORD - PAS-DE-CALAIS
	DE2 - BAYERN	**EE**	EE0 – EESTI		FR4 - EST
	DE3 - BERLIN	**IE**	IE0 – IRELAND		FR5 - OUEST
	DE4 - BRANDENBURG	**EL**	GR1 - VOREIA ELLADA		FR6 - SUD-OUEST
	DE5 - BREMEN		GR2 - KENTRIKI ELLADA		FR7 - CENTRE-EST
	DE6 - HAMBURG		GR3 – ATTIKI		FR8 - MÉDITERRANÉE
			GR4 - NISIA AIGAIOU, KRITI		FR9 - D+PARTEMENTS D'OUTRE-MER

Table A1 (cont.) The 85 NUTS 1 regions and 12 NUTS 0 = NUTS 1 country-regions

IT	ITC - NORD-OVEST
	ITD - NORD-EST
	ITE - CENTRO (I)
IT	ITF - SUD
	ITG - ISOLE
CY	CY0 - KYPROS / KIBRIS
LV	LV0 - LATVIJA
LT	LT0 - LIETUVA
LU	LU0 - LUXEMBOURG (GRAND-DUCHÉ)
HU	HU1 - KOZEP-MAGYARORSZAG
	HU2 - DUNANTUL
	HU3 - ALFOLD ES ESZAK
MT	MT0 - MALTA
NL	NL1 - NOORD-NEDERLAND
	NL2 - OOST-NEDERLAND
	NL3 - WEST-NEDERLAND
	NL4 - ZUID-NEDERLAND
AT	AT1 – OSTÖSTERREICH
	AT2 – SÜDÖSTERREICH
	AT3 – WESTÖSTERREICH
PL	PL1 – CENTRALNY
	PL2 - POLUDNIOWY
	PL3 - WSCHODNI
	PL4 - POLNOCNO-ZACHODNI
	PL5 - POLUDNIOWO-ZACHODNI
	PL6 - POLNOCNY
PT	PT1 - CONTINENTE
	PT2 - REGIÃO AUTÓNOMA DOS AÇORES
	PT3 - REGIÃO AUTÓNOMA DA MADEIRA
RO	RO1 - MACROREGIUNEA UNU
	RO2 - MACROREGIUNEA DOI
	RO3 - MACROREGIUNEA TREI
	RO4 - MACROREGIUNEA PATRU
SI	SI0 - SLOVENIJA
SK	SK0 - SLOVENSKA REPUBLIKA
FI	FI1 - MANNER-SUOMI
	FI2 - ÅLAND
SE	SE0 - SVERIGE
UK	UKC - NORTH EAST
	UKD - NORTH WEST
	UKE - YORKSHIRE AND THE HUMBER
	UKF - EAST MIDLANDS
	UKG - WEST MIDLANDS
	UKH - EAST OF ENGLAND
	UKI - LONDON
	UKJ - SOUTH EAST
	UKK - SOUTH WEST
	UKL - WALES
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