

Geographies of Knowledge Production in Europe

Tomas Hanell & Jörg Neubauer

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Stockholm, Sweden
2006

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Preamble

In current discourse the knowledge economy is viewed as the primary saviour of European competitiveness. By increasingly focusing on economic activities that utilise knowledge and innovation as the primary value-adding feature rather than cheap labour or available raw materials the EU should be able to increase its constantly weakening competitive position *vis-à-vis* North America and the fast growing economies in South and Southeast Asia. In the Lisbon European Council in March 2000, the European Union set a strategic goal for the next decade “of becoming the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion”. There is thus an implicit expectation that an increasingly knowledge-based economy would automatically generate larger economic growth and prosperity.

Before trying to illuminate further on that issue there is however a need to establish exactly how the knowledge economy could be operationalised to quantifiable measures. A generally utilised option here is the division of the knowledge economy into input and output variables. The former could be characterised as the actual endowments of the knowledge production system and include such issues as the educational level and knowledge of the population, the social capital of the population, the amount of money invested into education or the number of students, investments into research and development (R&D), etc. Output variables could be regarded as measurements of the economic or other output of the regional research environment and include, in addition to direct economic measurements such as GDP, issues such as the number of issued patents or patent applications or employment within certain knowledge-intensive branches.

Thus the main question here centres on the patterns of knowledge economy inputs and outputs in Europe and how are these distributed among the regions of the continent.

While the input case factors mentioned above can clearly be grouped under an input heading, in respect of outputs, boundary drawing is rather more sensitive. One possible distinction here could be between direct and indirect stimulation of the knowledge economy. Regarding input variables the stimulatory effect is rather more direct in character while in the output case it acts indirectly. Nonetheless, the two groups probably covariate strongly and therefore linkages between them will also be described

There is, on a broad level, a clear link between the knowledge economy and what has been termed, human capital, which in general terms may encompass issues such as knowledge, skills or other personal attributes (for instance perseverance). In general, investments in human capital probably (on average) provide increasing economic returns for the individual. While this most certainly can also be expected to hold true for economically less advanced nations, it is doubtful whether this is universally applicable for all of the more advanced economies, especially when moving the scope of analysis from the national to the regional or local level. Indeed, even the OECD states that:

"... investment in human capital may yield benefits to the economy at large. The collective economic impact should, in principle, be identifiable in the rate of economic growth, but in practice the impact has been difficult to confirm and quantify."¹

The ultimate question then is whether the knowledge economy truly is the "knight in shining armour" for each and every European region or whether the local and regional mix of endowments implies that there are also other pathways to prosperity. This subject is discussed in the final section of the report.

A core concept of the knowledge economy is that of the *immaterial asset*. While material assets diminish in line with their consumption, immaterial assets adversely increase. Immaterial assets are often subdivided into human and social capital, in this paper however we will stick to the former concept alone.

On the regional level the number of *available and comparable* indicators for a group of 30 or so European countries is understandably limited. This paper will therefore focus on some selected core themes with regard to knowledge production and the geographic patterns connected to it in Europe with special attention on the Nordic Countries and the Baltic Sea Region. In addition to the coverage of the EU27 countries as well as Norway and Iceland, St Petersburg, as well as the rest of North West Russia is also, where feasible, included in our analysis. The primary regional unit of analysis used here is NUTS 2 unless otherwise specifically stated.

This report is a contribution to the conference "*Investing in Research and Innovation – Exchanging European Experiences in a Nordic Context*" held in Copenhagen, Denmark 16-18 October 2006. The event is jointly organised by the Nordic Council of Ministers and the European Commission, Directorate-General for Research and Directorate-General for Enterprise and Industry.

The report has been written by Tomas Hanell and Jörg Neubauer of Nordregio, with the assistance of Michael Bentlage, who was responsible for the cartography.

Helsinki and Stockholm, October 2006

¹ OECD, 2001, p. 3-4

Patterns of knowledge production in Europe

Substantial variety exists in Europe when it comes to spatial patterns of knowledge, where research and development investments are targeted, and where research activities are carried out. This section deals with a number of these issues focusing both on commercial and academic research and the educational level and skill of the workforce as well as on knowledge intensive labour markets.

Ten European regions account for 30% of R&D

Expenditure on research and development (R&D) remains the primary measurement of a region's commitment to increase its knowledge base. By increasing R&D a region aims to increase the knowledge component in its economy in the hope of using these investments to devise new applications, which in the long-term they hope will sustain economic growth.

Contributions can either come from the business sector, the government sector or the higher education sector but also from the private non-profit sector. The overall target set by the Barcelona European Council aims at reaching an expenditure volume corresponding to 3 percent of the GDP in 2010, two thirds of this to be financed by the private sector.

Table 1: Total R&D expenditure as a share of GDP in 2004

Total R&D expenditure as a share (%) of GDP in 2004		
World	EU15	NMS, BG, RO
Japan 3.2	Sweden 3.7	Slovenia 1.6
The U.S. 2.6	Finland 3.5	Czech R. 1.3
EU25 1.9	Denmark 2.6	Estonia 0.9
China 1.3	Germany 2.5	Hungary 0.9
Russia 1.2	Austria 2.3	Lithuania 0.8
	France 2.2	Poland 0.6
	Belgium 1.9	Slovakia 0.5
	The U.K. 1.9	Bulgaria 0.5
	Luxembourg 1.8	Latvia 0.4
	The Netherlands 1.8	Romania 0.4
	Ireland 1.2	Cyprus 0.4
	Italy 1.1	Malta 0.3
	Spain 1.1	
	Portugal 0.8	
	Greece 0.6	
EEA		
Iceland 3.0		
Switzerland 2.6		
Norway 1.8		

Preliminary data: DK, EE, FR, GR, NL. Eurostat estimates: AT, DE, SI. Data for 2003: CH, CN, GR, IT, JP, LU, NO, PT, UK, US.
Data source: Eurostat, OECD

Today a rather modest share of 1.9 % of the EU25's GDP – when compared to the US or Japan – is spent on R&D (Table 1). In the US and Japan however,

expenditures are mainly allocated to experimental development while the EU25 focus is generally on applied research. In absolute terms, expenditure on R&D has, with the exception of the last five years, seen a steady growth.

The lion's share finances R&D within Europe's core economies of Germany, France and the United Kingdom. In contrast, expenditures on R&D are generally poor in Southern and Eastern Europe. On a national level currently only the Nordic countries of Finland, Sweden and Iceland meet up to the 3 percent expenditure target.

Furthermore the EU's overall investment in R&D is actually based on the expenditure of only a few region's all of which are located in the EU15 (Figure 1). The top ranking positions are dominated by German and Nordic regions led by Braunschweig² (8.7% of GDP spent on R&D). In the New Member States (NMS) the most R&D intensive region is Stredni Cechy (2.6%) surrounding Prague. This region does however remain far below the levels of the top regions in the EU15 and has in addition witnessed a decline in R&D funding in recent years. Research investment is thus highly concentrated within the European Union and EEA countries with 30% of all R&D investment concentrated to only ten regions, these ten regions account for a mere 12% of the corresponding population.

R&D funding varies significantly from country to country, especially in the top spending countries such as Finland or Germany. Other larger regional disparities in funding intensity are for example to be found in Norway, Sweden, the UK, the Czech Republic and Poland.

Especially in Eastern Europe, where spending is low, regions housing the capital and/or their surrounding regions are clearly those most favoured in terms of R&D funding. Following the NUTS2 divisions the extreme here is Bulgaria, which distributes around 80% of its national R&D expenditure to the Yugozapaden region. In the Czech Republic, Hungary and Romania more than half of the funding available is distributed to the capital region. Thus here metropolitan areas are by far the strongest receivers of R&D funding. In the EU15 less strong but still substantially capital-concentrated R&D funding is evident for example in Finland (62%), Greece (53%), Austria (49%) and France (42%). However, in the old EU member states concentration of R&D to the capital is less pronounced. Furthermore, not all metropolitan areas are strong on R&D. Several medium-sized urban areas in the EU's core and its northern parts are also favoured in this regard, the most outstanding examples being Braunschweig in Germany and Oulu in Finland.

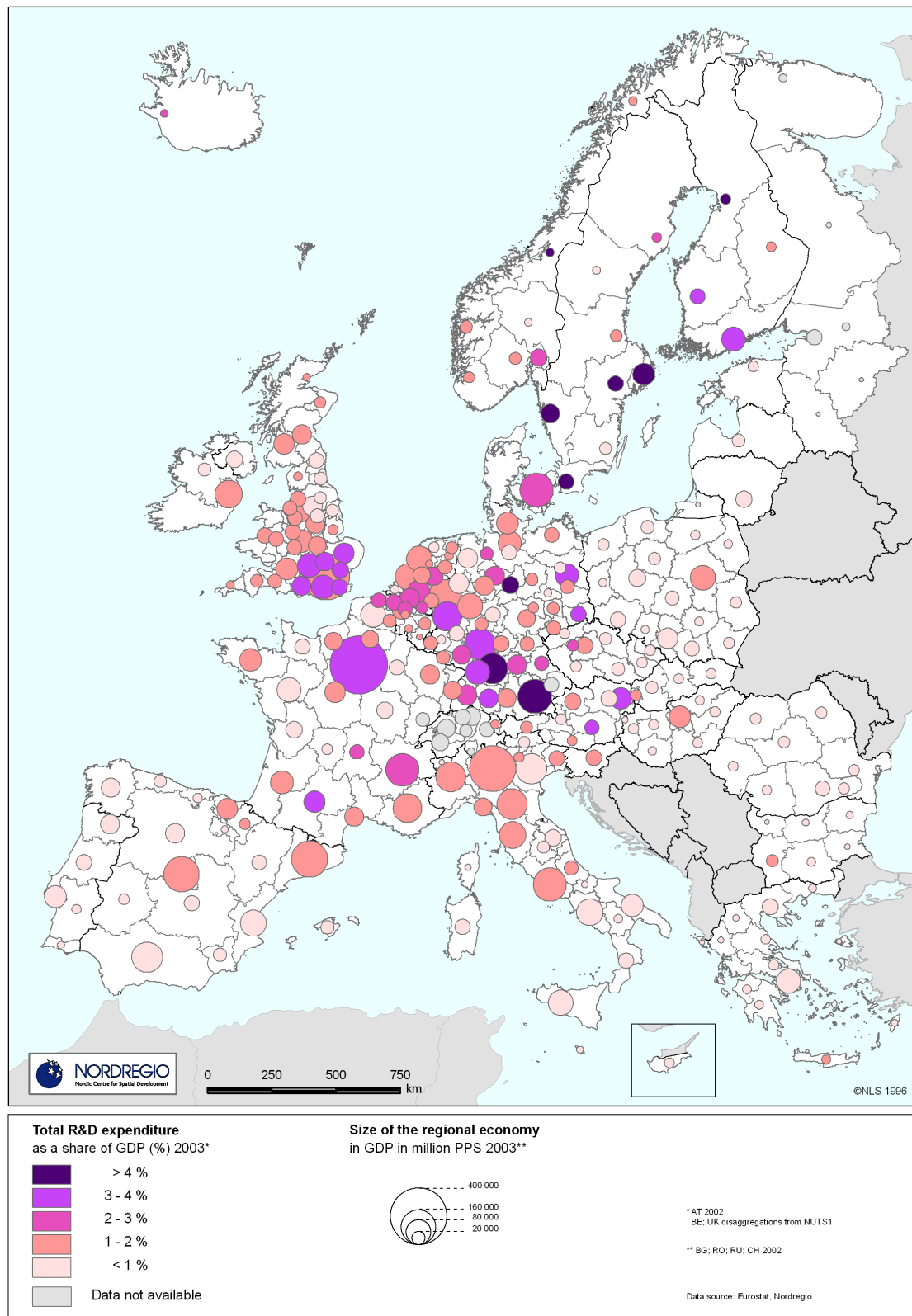
The private sector dominates R&D investment in Europe

The major part of the EU25's R&D expenditure stems from the business sector (54%), two thirds of it is spent in manufacturing and one third in services (Annex 1). This is, however, modest compared to the US, Japan or China. The private sector dominates R&D investment especially in the EU15 with the exception of Austria, Greece, Italy, Portugal, Spain and the UK. In Luxemburg, Finland and Switzerland already today more than two third of R&D expenditure originates

² The region has among others substantial car manufacturing (Volkswagen in Wolfsburg), chemical industry and machine building (in Salzgitter and Peine) as well as a large university (in Göttingen).

from the private sector. Other intensive spending countries also maintain a high share of private sector financing, such as Sweden and Germany.

Figure 1: Total R&D expenditure as a share of GDP 2003



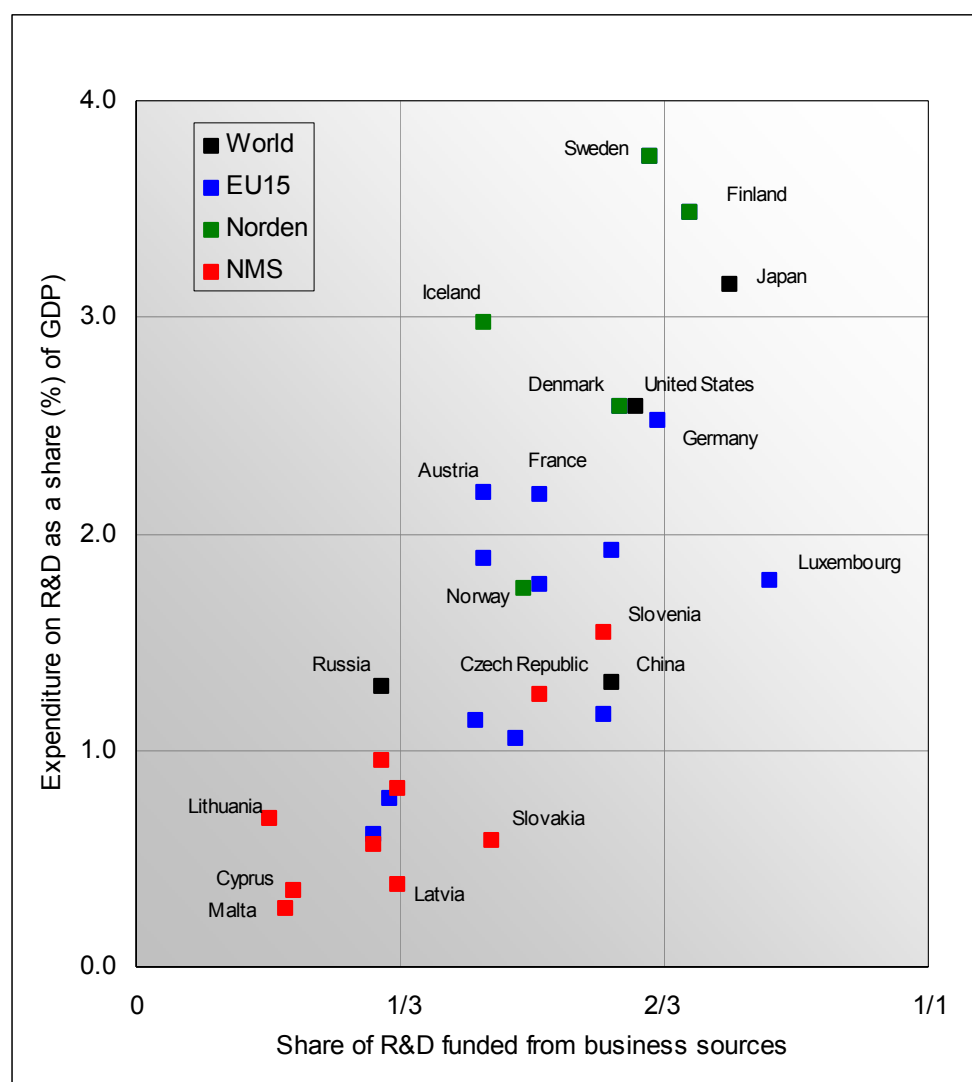
A stronger involvement of the private sector in R&D financing clearly increases the overall level of a country's R&D volume (Figure 2). In general this applies all over the EU territory as well as for non-EU countries.

The governmental sector (35%) is the second major contributor in the EU where it is more important than in the other world economies. The public sector dominates in the New Member States, except for the Czech Republic and Slovenia, and in the cohesion countries. The Russian Federation also finances most of its research from governmental sources.

Norway and Iceland fall in between the two extremes as the financial base of R&D is roughly balanced between the private and the public sectors.

The remaining R&D expenditure originates from other (third sector) national sources (2%) and from a comparatively large and increasing share from abroad (9%). The latter sector is particularly relevant in Austria, Latvia, Malta and the UK, where every fifth Euro invested in R&D comes from abroad.

Figure 2: Business activity in R&D and the overall intensity of spending 2004



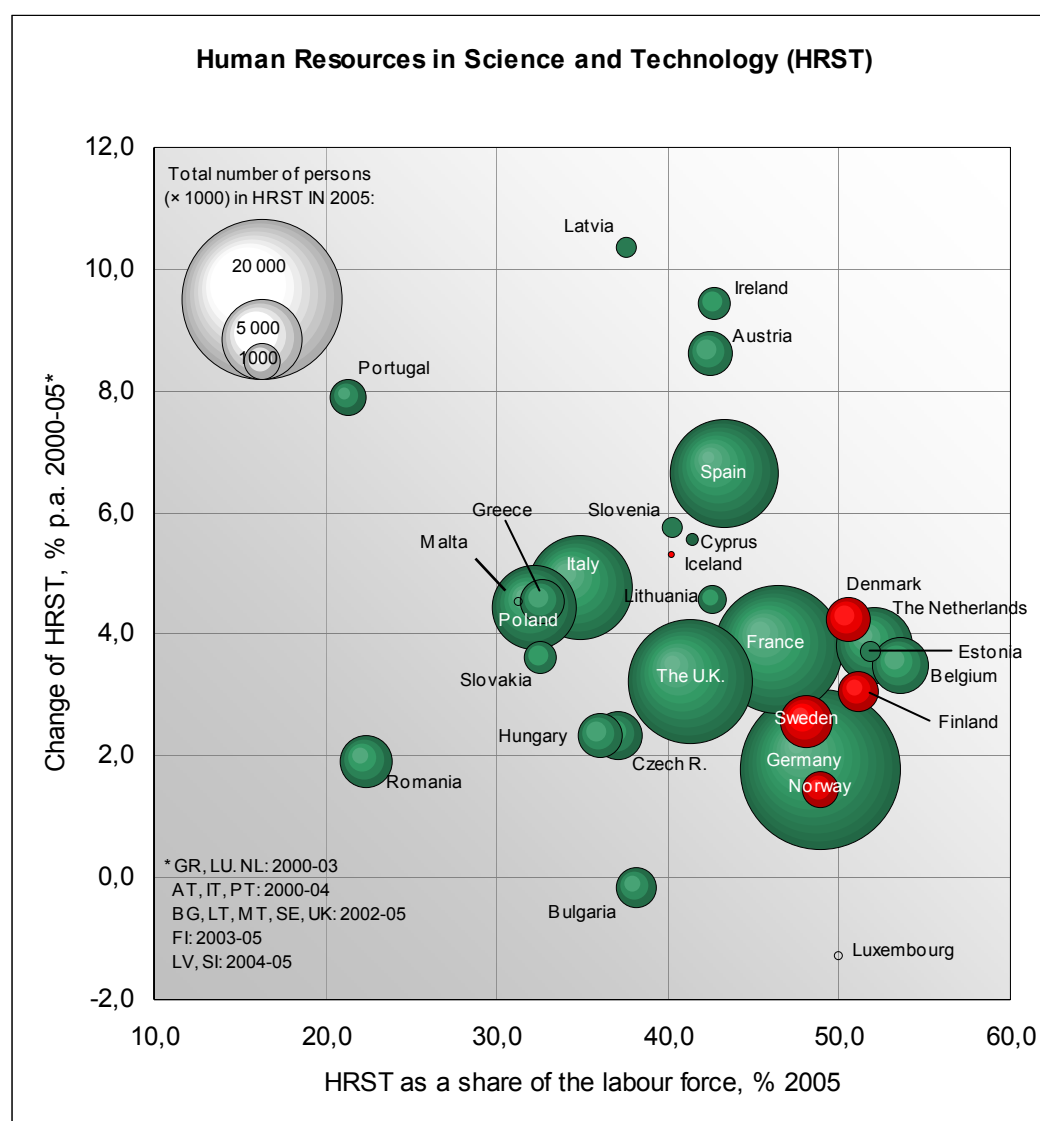
Data source: Eurostat

In the Nordic countries domestic financing predominates, except for Iceland with 14% of R&D comes from outside the country. The situation in Iceland is thus nearly on a par with the situation in countries with substantial Foreign Direct Investment, such as Estonia, Lithuania and Cyprus.

Nordic countries still strong on human resources in S&T

The availability of highly qualified workers is *the* core prerequisite for the knowledge economy. This group of science and technology personnel are in a wider sense often labelled as Human Resources in Science and Technology (HRST), which can be further sub-divided into two groups of persons, namely those with higher qualifications, i.e. persons with tertiary education (ISCED 5 and upwards), or those with occupations where such a qualification is normally required.

Figure 3: Number, share and growth of Human Resources in S&T



Data source: Eurostat

The former group constitutes the potential supply on the labour market while the latter corresponds in the main to the level of demand. Within the EU27 (and also including the EEA countries) some 91 million persons fulfil such qualifications, accounting for up to 42% of the European labour force.

Figure 3 presents data on the total number of HRST, and its changing level between 2000 and 2005, as well as the share of these persons from the total labour force. On the country level the general pattern is that smaller and medium-sized countries – if situated in Northern and Western Europe – tend to have higher shares of persons with such skills. In this respect the Nordic countries (apart from Iceland), marked in red, are primarily surpassed only by the Benelux countries and Estonia. However, this lead might not be there for too long as the growth rates of countries such as Latvia, Ireland, Austria and Spain, or in the Nordic context Iceland, are profoundly higher.

Many central- and southern East-European countries however lag substantially behind their western and northern counterparts, the divide is moreover aggravated by slow or, as is the case of Bulgaria, even negative growth rates.³

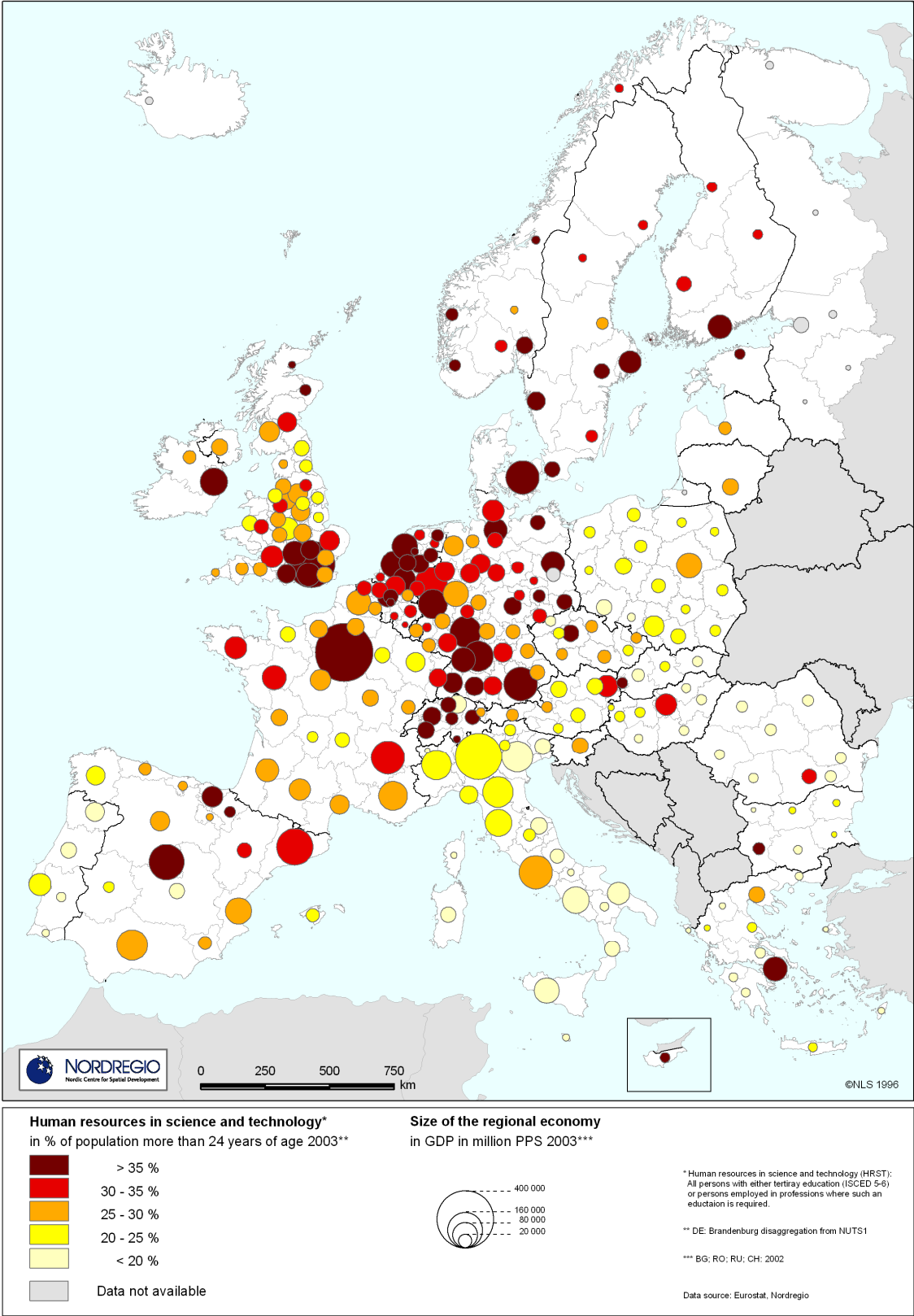
The regional distribution of these human resources also displays the very familiar pattern of the Blue Banana, supplemented by national capitals and larger metropolitan areas (Figure 4). In virtually all European countries capital and other metropolitan areas account for the lion's share of this human capital. The most prominent exceptions to this pattern include more peripheral regions such as Åland in Finland, the Scottish Highlands and Islands, the Norwegian West Coast and the Basque country in Spain.

In general, Southern Europe also lags behind on the regional level. Of the 25 European regions (for which data exists) that have the lowest relative numbers of HRST, seven are in Romania, three in Italy and six in Greece and Portugal respectively.

In most countries national strategies currently exist that aim to increase the share of those persons with a higher education. Particularly in the Nordic countries however the question of whether a limit has now been reached in respect of the potential continued growth of the highly skilled and highly educated labour force is increasingly posed. Indeed voices are being raised that this is an unrealistic path since currently in many Nordic metropolitan areas the largest labour shortages are *de facto* within low skilled tasks rather than top of the scale functions.

³ Due to its specific economic structure Luxembourg displays in this respect large variations from one year to the next.

Figure 4: Regional distribution of human resources in S&T 2003



Knowledge intensive employment concentrated to Europe's economic core

Another way of viewing Europe's highly qualified human resource endowment is to look at the location of knowledge intensive industries including both manufacturing and services (Figure 5). Employed persons with knowledge intensive occupations are highly concentrated to the labour markets within the European pentagon, especially those of southwest Germany and northern Italy.

It is illustrative that this area in southwest Germany only contains approximately 6% of all employed persons within the EU, while its' European share of employment within the knowledge intensive industries sector is nearly twice as high.

In addition to the absolute European core, the rather small and highly dynamic high-tech manufacturing belt across northwest Spain, comprising Bilbao, Aragon, Navarra and Catalonia, is also a strong employer of highly qualified persons. Furthermore, a considerably large share of employment in the Czech Republic, Slovakia, Slovenia and the northern parts of Hungary is knowledge intensive.

While in all of these areas high-tech manufacturing industry is the dominant employer (Annex 2), the remaining areas encompassing Europe's highly qualified human resource endowment are specialised in knowledge intensive market services (Annex 3), the Nordic countries included. In contrast with manufacturing industry, capital cities and/or their surroundings usually comprise the lion's share of a country's knowledge based service employment (Annex 3). This applies, for example, to the capital regions in the Nordic countries as well as to Paris (Ile de France) or Berlin. Furthermore in Austria (Vienna), Spain (Madrid), Portugal (Lisbon) and the New Member States this type of activity is almost exclusively carried out in the capital cities.

A totally different picture emerges when focussing only on the educational level of a population. Data for 183 cities from the Urban Audit indicates that the partially hierarchical pattern with regard to e.g. knowledge-intensive employment is not equally evident when it comes to the actual educational level of the population.

Figure 6 depicts the 25 European core cities where the educational level is highest, i.e. the share of population that have attained a degree on level 5 or 6 in compliance with the ISCED classification. (Figures from e.g. France and Spain are missing from this data set which probably biases the result slightly.) Nonetheless, and not surprisingly, Cambridge emerges as the European city with the highest educational level. Other typical university cities, such as Freiburg, Göttingen and Leipzig in Germany, Utrecht in the Netherlands or Tartu in Estonia, are also included on the list. However, cities with a high-tech manufacturing profile, such as Oulu or Tampere in Finland or Aberdeen in the U.K., also rank highly in this respect. Of the European capitals the populations in Tallinn, Helsinki, London, Amsterdam and Warsaw have the highest levels of education. Other nationally significant administrative centres, such as Karlsruhe with the *Bundesgerichtshof* (the German High Court), are also included among the top cities in this respect.

Figure 5: Regional employment in knowledge intensive industries 2005

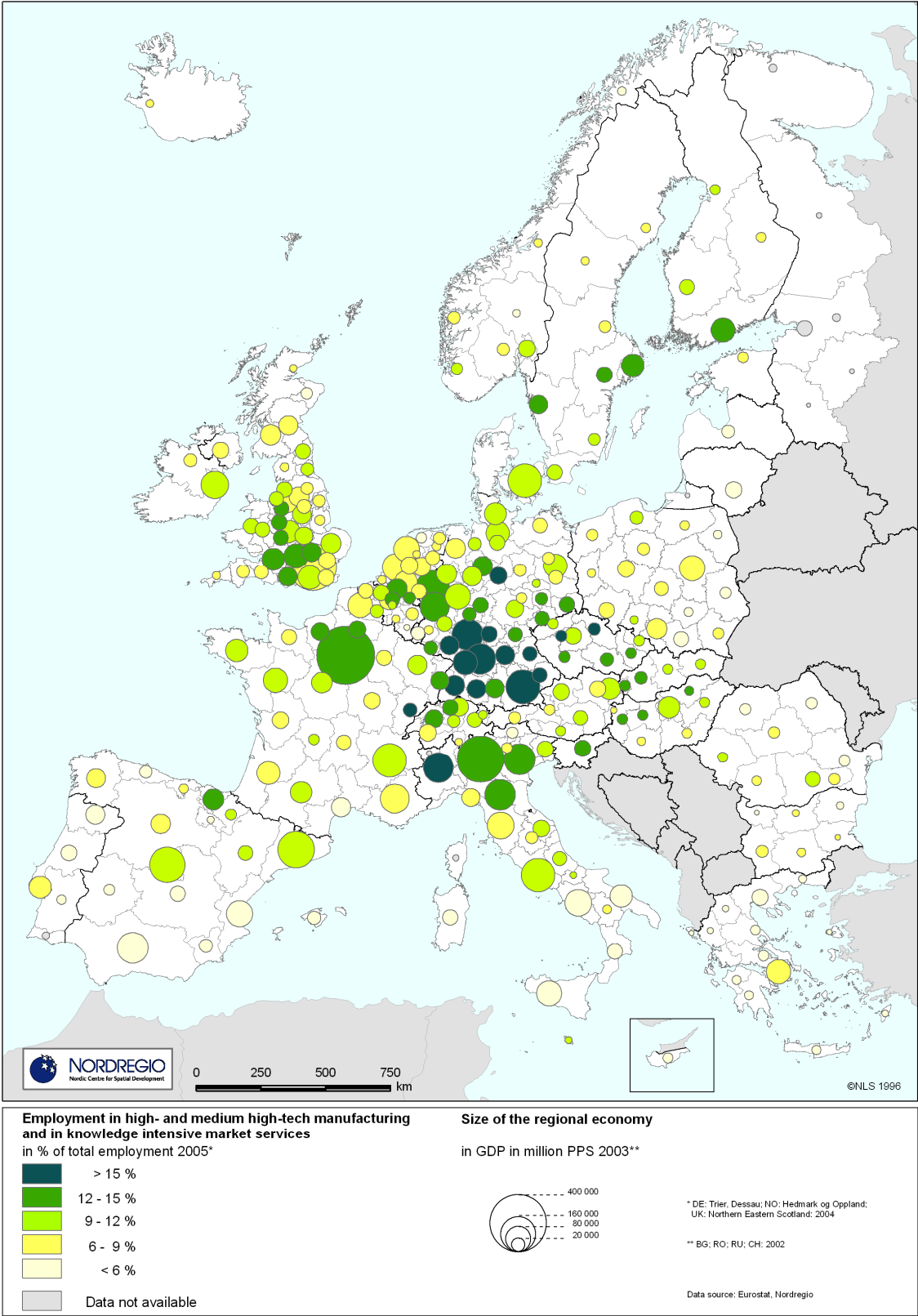
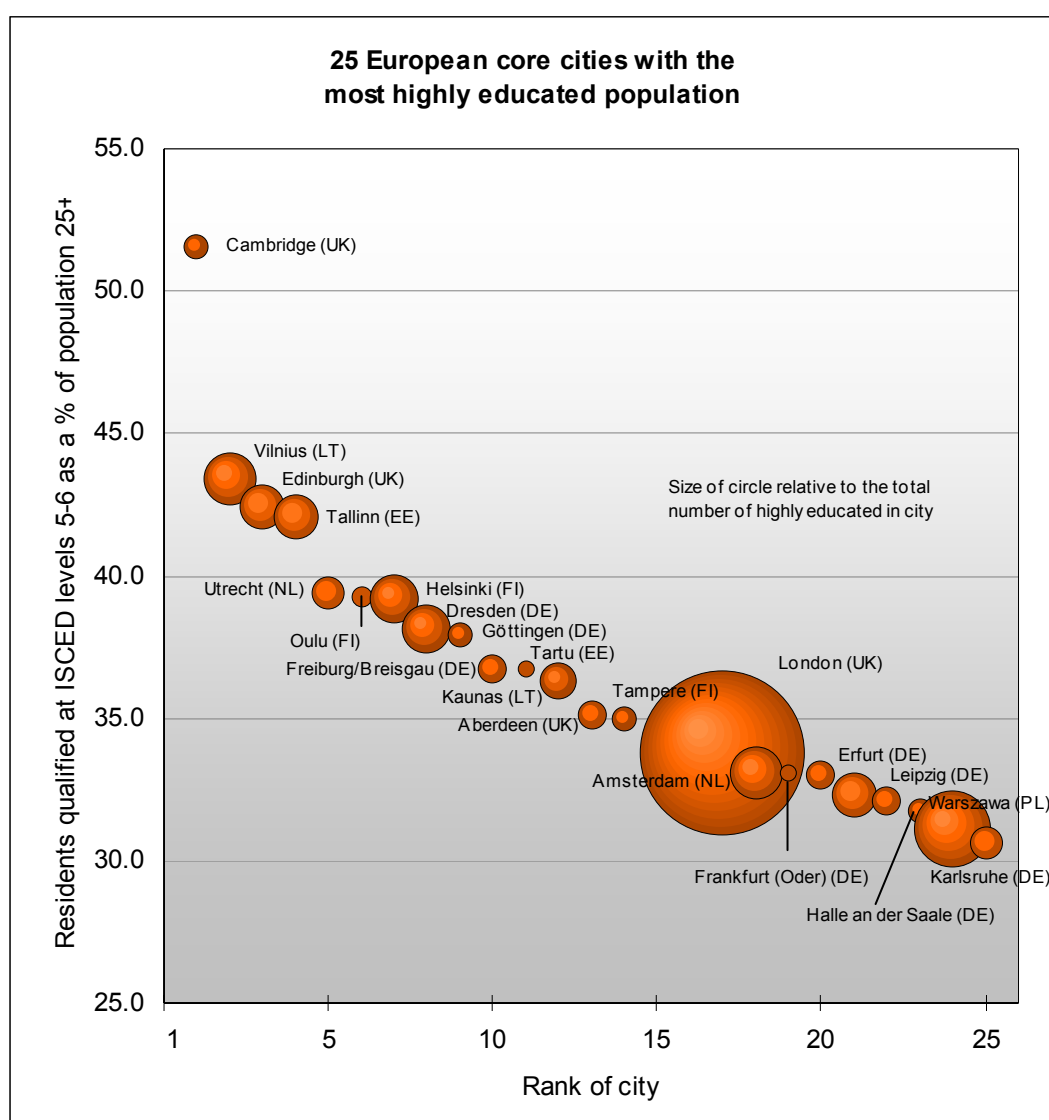


Figure 6: European cities with the highest levels of education



Note: Data for cities in France, Malta and Spain missing.

Data source: *The Urban Audit*

Despite this rather diverse mix of cities with a population that has a high level of education, the vast majority of these cities share the fact that academic research is being carried out in them. The next section will thus look more closely at specific academic patterns in Europe.

Most of the top European universities are located within the Pentagon

Historically, universities have been the main, and indeed often the only, *milieus* for science and innovation. In the last thirty to forty years the substantial rise in corporate and/or other private sector research has however seen a steady loosening of the formerly umbilical ties between universities and the local or national economy. Currently some 54% of all R&D funding in the EU stems from

private sources, i.e. largely outside the academic field⁴. Indeed, currently there is strong pressure on universities to more actively seek financing from the private sector. More generally, universities are being challenged to more vigorously contribute to local and regional development. This does not imply that universities are necessarily seen as significant suppliers to the local workforce, but that the societal and local/regional effects of their work have to be taken into account. This mission is often labelled as the “third task” of universities. In e.g. Finland a national evaluation process is currently underway in respect of this sector.

Nonetheless, from a “knowledge economy” point of view, a core issue here is that the supply of qualified labour, even today, is by and large in the hands of the universities and other higher education institutions. This is not to ignore the fact that the highly educated are among the most mobile groups in the labour force and the location of a university does not in any way guarantee that the future job of the student will be in the vicinity of the place where his or her studies were carried out. Another important issue here is that universities still today carry out important research tasks in the fields of technology and medicine, as well as in so called primary or basic research, a prerequisite for truly new and innovative thinking.

In this respect universities have a dual role in the knowledge economy, both as suppliers of raw material to the labour market and as producers of knowledge.

Universities are difficult to compare. The measurement of the qualities of universities globally by the Institute of Higher Education of Shanghai Jiao Tong University is one of the most cited works in this field thus providing a useful background for the broad mapping of the quality of academic research, at least on a continental scale. The measurement considers some 2 000 universities on all five continents and is based on five groups of criteria, which are (respective weight in parentheses):

- *Alumni* of an institution winning Nobel Prizes and Fields Medals (10%)
- Staff of an institution winning Nobel Prizes and Fields Medals (20%)
- Highly cited researchers in 21 broad subject categories (20%)
- Articles published in *Nature* and *Science* (20%)
- Articles in Science Citation Index-expanded, Social Science Citation Index, and Arts & Humanities Citation Index (20%)
- Academic performance with respect to the size of an institution (10%)

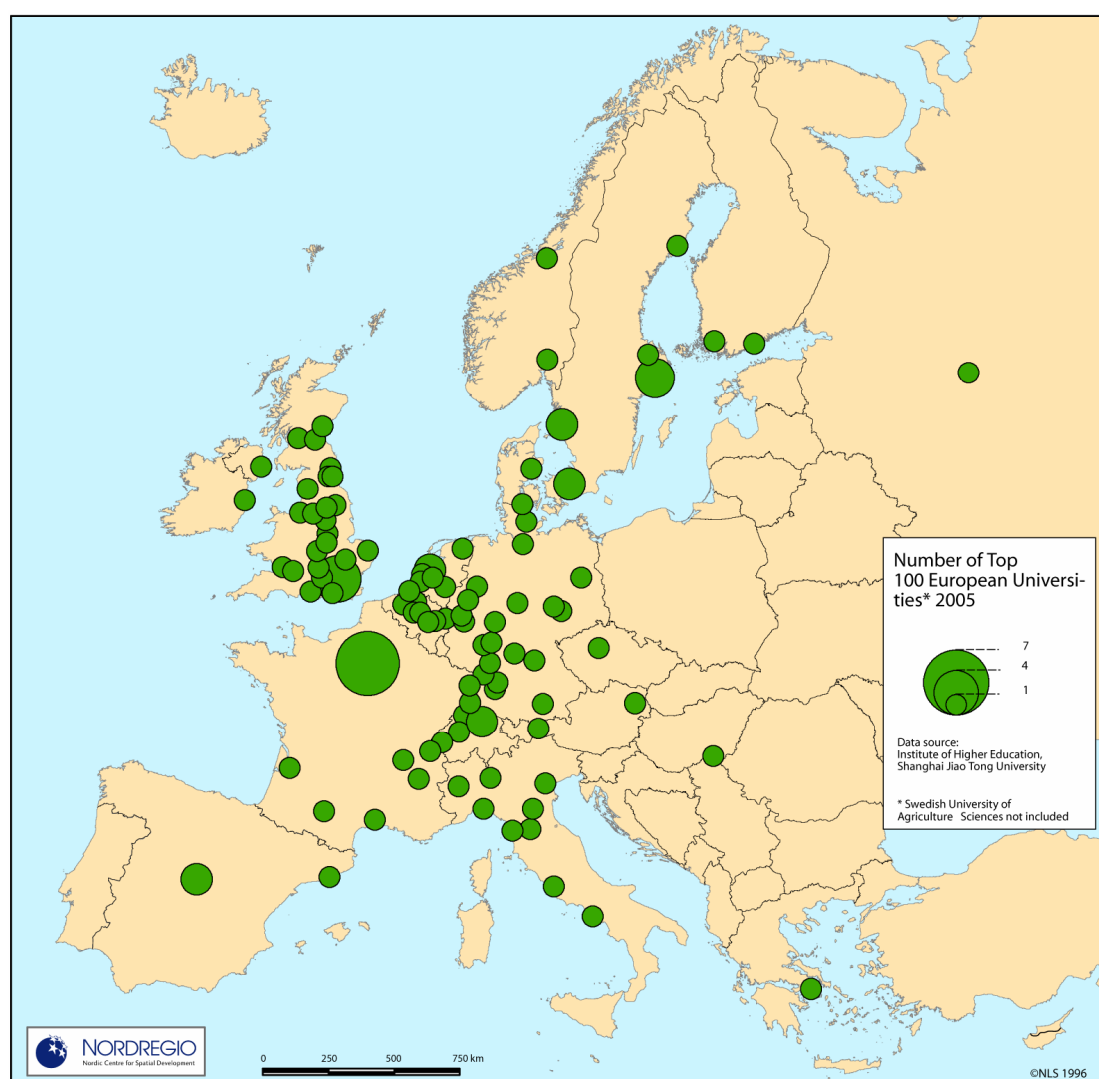
Although there are universities in virtually every corner of the European continent, the location of highly ranked universities is, by and large, a matter for the Pentagon. Of those 100⁵ ranked highest in Europe, nearly a third (30) are in the UK, nearly a fourth (23) in Germany and 13 in France, followed by nine in Italy, the Netherlands and Sweden respectively. Of the larger European countries, Russia, Poland and Spain are clearly underrepresented, and more generally, Eastern Europe in its entirety is virtually void in this respect (Figure 7). Globally however, most leading universities are located outside Europe, primarily in North America.

When moving down to the city level Paris, with seven universities, has the highest score in Europe. London as a European academic centre is in this respect also outstanding. Scandinavia is well represented, with Stockholm, Copenhagen and Gothenburg represented in the leading *milieux*.

⁴ Universities do however also conduct privately financed research.

⁵ Actually 123 universities altogether, as there are several universities sharing a same ranking.

Figure 7: Leading university cities of Europe 2005



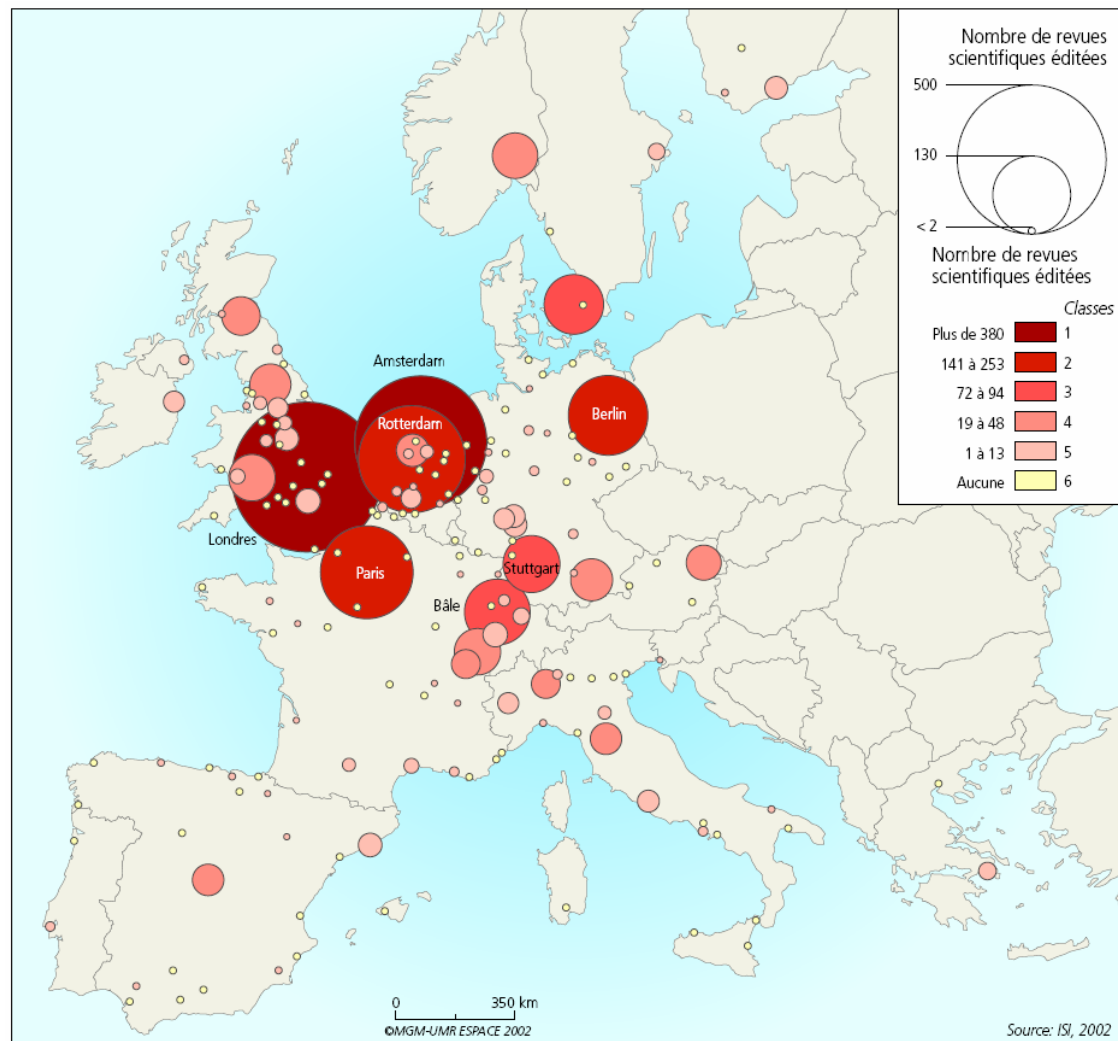
Data on private and public institutions participating in the 5th framework programme also provides considerable information as to the geography of academic knowledge production in Europe (Rozenblat & Cicille, 2003). By and large, this is also a metropolitan area issue where the participation and dominance of large cities such as Paris, London, Madrid or Rome is to be expected. The only major exceptions to this size rule in this respect are the Nordic capital cities which, despite their limited size, have participated in the programme vigorously and are nearly on a par with the largest West-European cities.

The number of edited scientific journals is another measurement of the activity and level of academic knowledge of a university. Those universities that "produce" a significant number of academic journals could also be expected to be among the "leading lights" within their respective fields, although naturally there are no definite quality assurances.

As with the geographical spread of the leading international universities in Europe, the editing of academic journals is also highly concentrated to the Northwest, with Southern Europe in particular lagging behind (Figure 8). Part of the explanation for this lies in the fact that the data source used (Institute for Scientific Information, Philadelphia, U.S.) is biased towards academic journals in

the English language. Nonetheless, Oxford is in this respect the leading academic publishing *milieu* in Western Europe, responsible for roughly a fifth of all journals published in Western Europe, although much of this is based not on the university as such but on the existence of large publishing houses in the city. Of the major cities, London, Amsterdam, Rotterdam, Paris and Berlin rank the highest.

Figure 8: Number of edited scientific journals in larger Western European cities



Data for Oxford (789 journals), Basingstoke (126) and Chichester (121) not displayed. The size of the circle refers to the number of edited scientific journals per city. The colours are merely categorical groupings of the same data. Source: Rozenblat & Cicille, 2003, page 45

In Sweden many of the largest universities (e.g. Uppsala or Lund) are located outside the major cities of Stockholm, Gothenburg and Malmö, which partly explains the low performance of these cities. In Norway again, which has a rather centralised university system in comparison with e.g. Sweden or Finland, the position of Oslo predominates. From a Nordic point of view Copenhagen is in this respect the primary academic *milieu* of the Nordic countries, Copenhagen being especially vigorous in medical sciences publications.

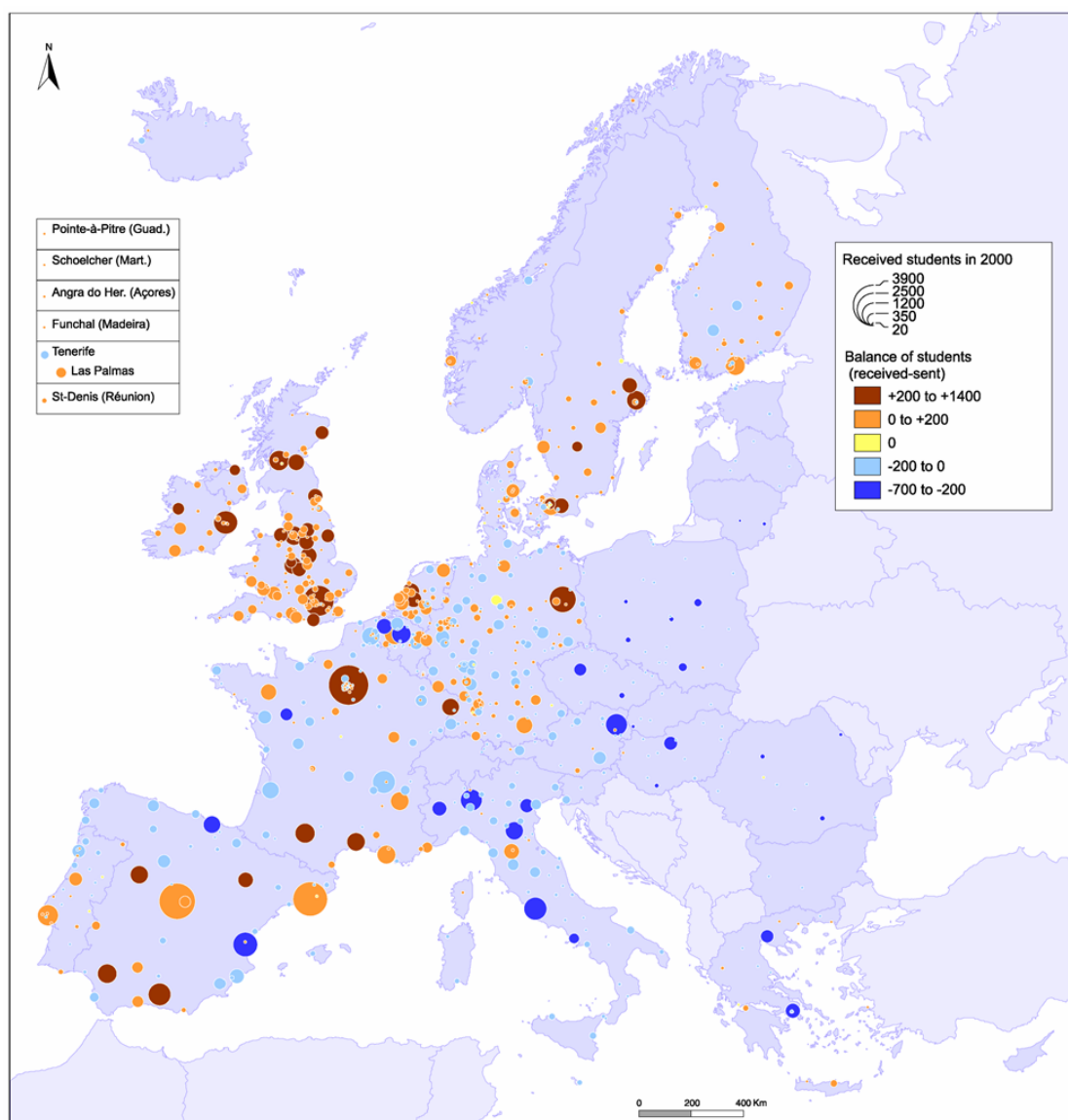
The absolute and relative number of exchange students is another measurement of the, at least perceived, attractiveness (and by extension, hopefully, quality) of higher education institutions. On the one hand universities can attract students from abroad by providing a high quality education and staff. On the other hand

the same universities can add value to their own output (i.e. graduates) by providing for an opportunity to study abroad. The positive effects of this internationalisation of the universities thus work both ways.

Figure 9 presents data on the European-wide ERASMUS student exchange programme. The sizes of the circles reflect the total number of students received. The colours of the circles depict the balance of sent and received students, where the brownish colours indicate a larger number of students received than sent, with the blue colours representing the opposite.

In this respect there is a significant divide between the universities of the Old and the New Member States. Virtually all universities in the NMS do not attract students to the same magnitude as their Old MS counterparts.

Figure 9: Number and balance of ERASMUS students in 2000



Source : Erasmus
© N. Cattán, G. Leseq, CNRS-Géographie-cités, 2003

Source: ESPON Map overview, 15 January 2005, at:
http://195.37.164.153/raumordnung/europa/map_collection/mapoverview111_en.htm

A second general trait here is that large cities tend, even in relative terms, to attract more students than small ones. This is probably not only the result of an actual quality difference between the universities but also a reflection of how well cities are known and of their prevailing image.

Finally, when looking at the balance of sent and received students, there are a number of substantial differences. Large cities attract far more students than they send out whereas the opposite holds true for smaller cities, Belgium, Italy and Greece constituting the primary exceptions. All NMS' universities also send out more students than they receive. The level of "internationalism" of the students from Eastern Europe and from smaller cities all over Europe is thus in a sense far higher than for other Western countries and for large cities. As international exposure is a key parameter in socio-cultural competence, this could tentatively act as a force shaping the future pattern of the European knowledge economy.

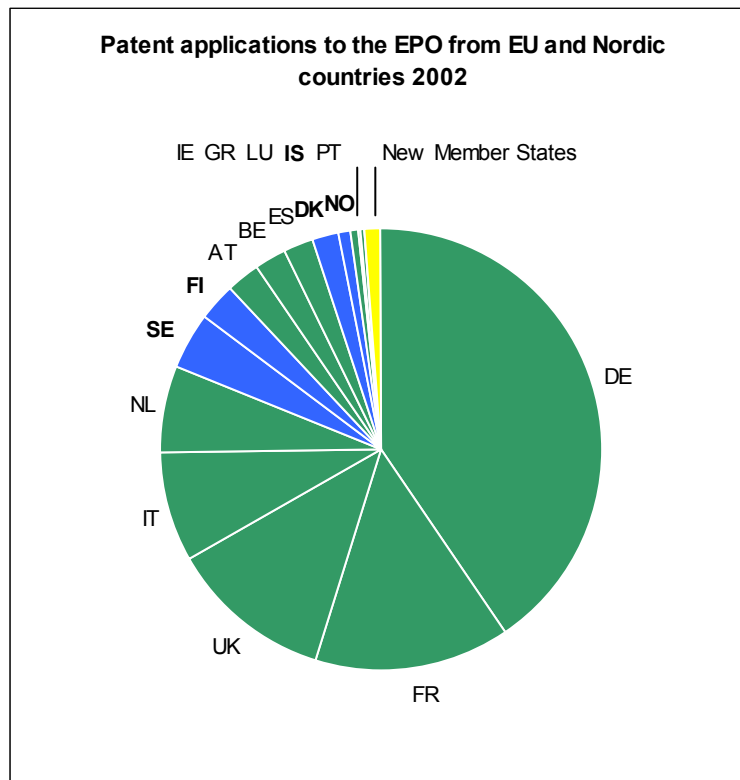
Four out of ten European patent applications are German

Patents represent those parts of the knowledge output which, based on specific ideas have been turned into practical applications. They measure a regions' inventive activity and its exploitation capacity in respect of knowledge in order to derive economic value. Not every practical application is patented however nor is every patent equally significant in terms of potential economic gain. Patent applications as measured here include those that have been filed at the European Patent Organisation (EPO) and are assigned to the inventor's place of residence or equally divided between them, in cases of an inventor team.

Patenting activity in the EU25 has steadily increased over the last 20 years, though recent years have seen this figure plateau somewhat. In 2002, the EPO granted around 60 000 patents or 1.3 patents per 10 000 inhabitants, which is the double number of just a decade ago. However, patenting in the EU is almost exclusively a EU15 activity (Figure 10) with Germany being by far the single largest filer (41%) of patent applications followed by France and the UK. However, the Nordic countries also make important contributions taking into account their small size.

As such then, taking population into consideration Finland, together with Sweden and Germany, is most active in filing around 3 patent applications per 10 000 inhabitants. This pattern is further pronounced on a regional level (Figure 11). Europe's patents are incubated firstly in its economic core, the Pentagon, with a major contribution from several regions in Southern Germany, and secondly in Nordic regions. The Dutch region of Noord Brabant, however, is most active (11 patents per 10 000 inhabitants) Thus, out of altogether 250 European regions only 10 regions in Germany, the Netherlands, France and Italy account for one third of all patent applications filed at the EPO. Those active regions tend to be part of an economic cluster i.e. in Southern Germany and North Italy/Eastern France. Patenting activity in the southern and eastern parts of the EU is rather low.

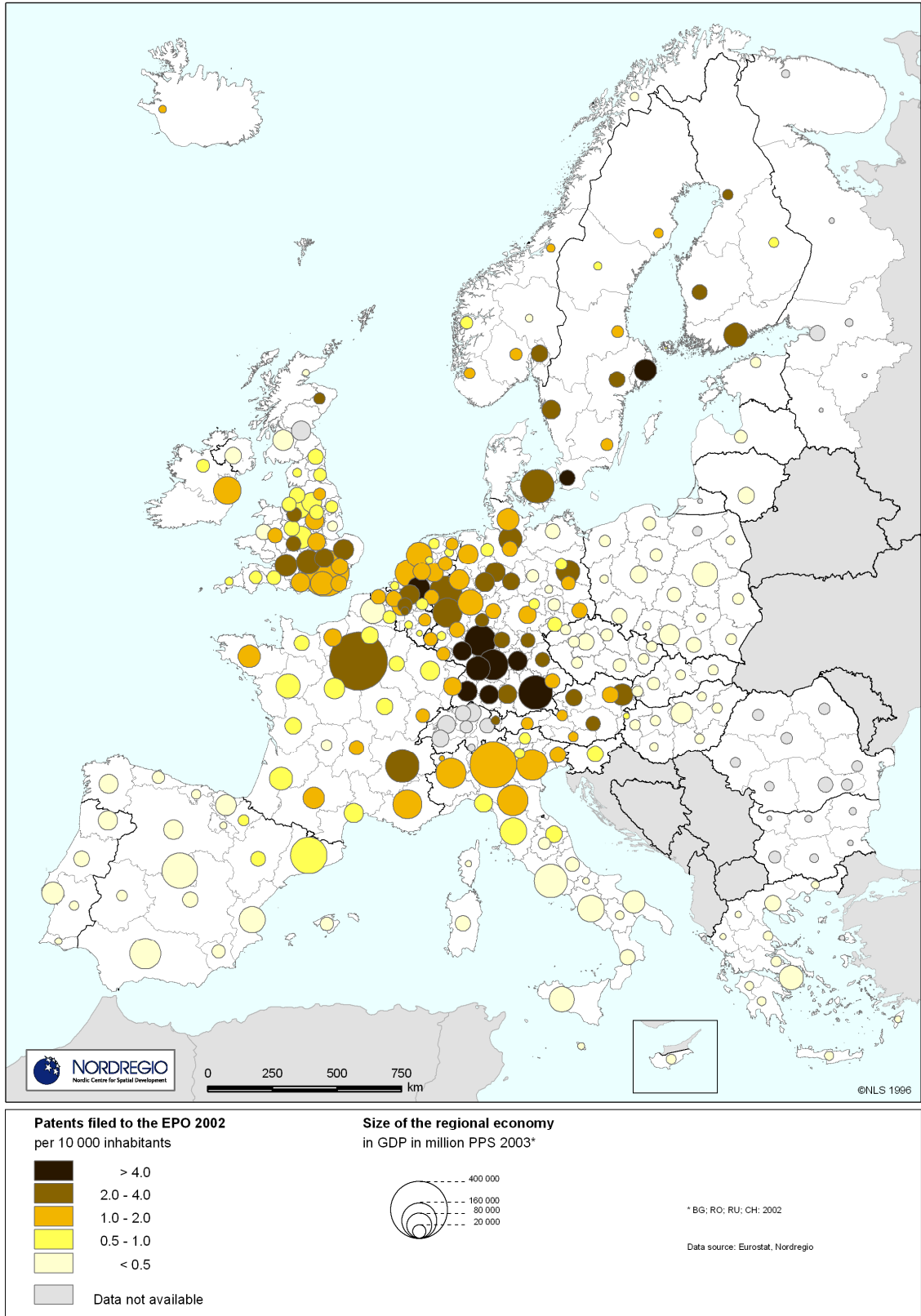
Figure 10: Patent applications filed at the EPO from EU and EEA countries in 2002



Data source: Eurostat

In the Russian Federation Moscow completely dominates patenting activities. One third of all applications filed at the Federal Service for Intellectual Property, Patents and Trademarks (ROSPATENT) in 2005 stem from the capital region (the city of Moscow incl. the surrounding region). In contrast, the country's second city, St Petersburg, contributes a mere 8% of all Russian patent applications. From the perspective of the Baltic Sea Region, St Petersburg nonetheless is the primary focal point as nearly all patent applications filed from Northwest Russia stem from there. In addition, much of the little remaining commercially innovative activity in this area takes place in the adjacent Leningrad region, based on the oil and ship building industry as well as on a mixture of businesses located in close proximity to the St Petersburg city boundary.

Figure 11: Regional distribution of patent applications filed at the EPO 2002



Manufacturing industry is the strongest commercial innovator

The availability of extensive R&D funding in a region is not necessarily a determining factor in the production of innovative knowledge. Exploitation of the knowledge base in order to file patent applications is far more dependent on the type of research and development conducted and as such is, in many cases, bound to specific geographical locations. In fact, the regions specialising in medium and high-tech manufacturing are among the strongest commercial innovators, if innovation is measured as patent applications. Consequently then, Europe's leading regions in high tech manufacturing file patent applications more intensively than do other regions. Almost the entire South German manufacturing cluster belongs to this category, regions such as Oberbayern or Stuttgart (Figure 12b) but also northern Italy and Spain with considerably less intensive R&D funding (Figure 12a). The Dutch Noord Brabant region, specialising in consumer electronics (e.g. Philips), is in a class of its own here.

Generally, regions in the Nordic countries differ from their West-European counterparts in that they, on average, spend more on funding R&D, though the output in terms of patents tends to remain smaller. One explanation for this is that in the Nordic regions knowledge intensive market services are more important. Since patenting activity in this sector is generally lower than within the manufacturing sector, the innovative "performance" remains modest in this sense. However, there nonetheless seems to be a typically Nordic gap between R&D spending and outcome in terms of patent applications, indicating a lower capability to capitalise and "productify" research and innovations. Åland, with a comparatively low level of R&D funding and - measured as a share of population - high innovativeness, is an exception here.⁶

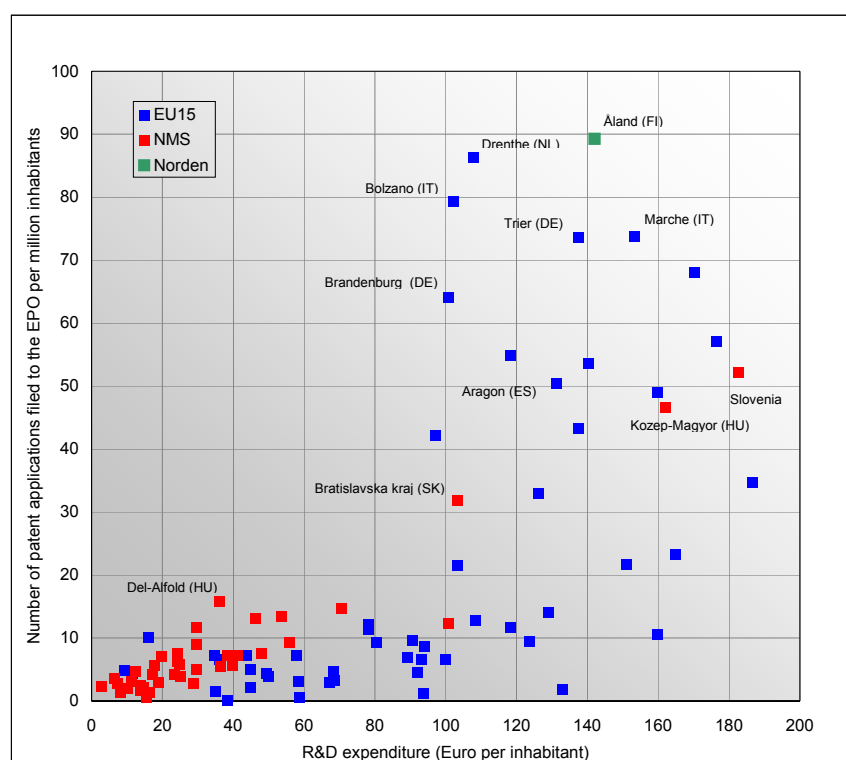
In the New Member States Slovenia's high-tech manufacturing industry is a productive innovator. The predominant funding of this type of research and development stems from business sources. However, this also holds true for the more service-oriented Nordic knowledge industries.

Despite, at times, fairly substantial R&D investment, the relative number of patent applications in several regions across the southern fringe of Europe remains rather modest, much more so than in many of their counterparts in the New Member States

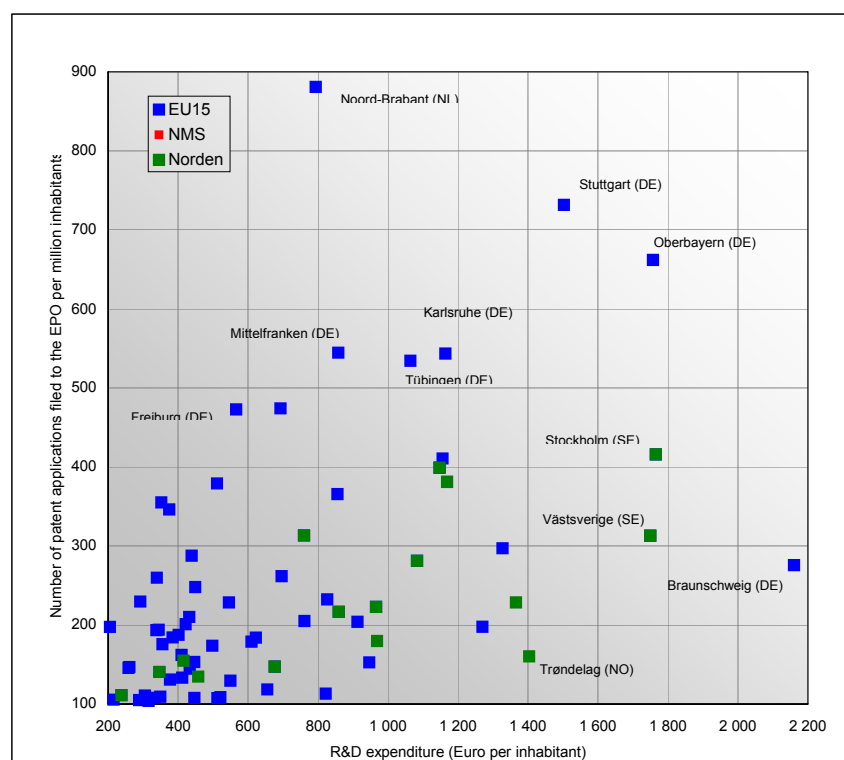
⁶ In this particular year there were altogether four filed patents from Åland, concerning for instance logistics software, a household water leakage alarm system and a docking station for Search & Rescue vessels.

Figure 12: R&D expenditure and patent applications in NUTS 2 regions 2002

a) Low funding regions (R&D expenditure 0-200 EUR per inhabitant)



b) High funding regions (R&D expenditure over 200 EUR per inhabitant)



Data source: Eurostat

Making sense of the patterns

The differing patterns of this knowledge production that have been described in this section do not make it easy to interpret the results in a coherent manner. Rather, there seems to be a multitude of different layers of knowledge production in Europe, largely depending on the various contexts and angles that have been taken. From this rather blurred image, certain traditional aspects are nonetheless discernible.

First, there is in most cases a clear core-periphery pattern to the structure of knowledge intensity in the economy. The only major exceptions to this are the Nordic countries. The Nordic countries are in a way the only major European macro region that is on the verge of entering a "knowledge economy", albeit with significant remaining differences between the countries.

Second, within virtually every European country the familiar divide between the capital and other metropolitan areas on the one hand and more remote regions on the other remains. There are exceptions to this, of course; in the Nordic countries especially northern Finland (primarily Oulu) stands out; in Germany, particularly Braunschweig.

Third, the East-West divide of Europe is also still clearly discernable. The New Member States are, in general, still in a disadvantageous position in most aspects of knowledge production. The currently extremely rapid growth in e.g. the Baltic States however indicates that this pattern might be altered within a reasonable timeframe.

Fourth and finally, there is also a clear divide between Northern and Southern Europe, where the former (including Northern Italy) has a clear advantage over the latter. The current dynamics indicate, perhaps with the exception of Spain, that this situation could be expected to remain in place for quite some time.

The logical next question then is, what effects do these factors have on the economic and social development of the European regions? This then will be the focus of the final section of this report.

Knowledge production and economic performance – missing links?

As stated at the beginning of this report, the knowledge economy is now expected to play the role of the saviour of Europe's lagging competitiveness. The role of innovation in fostering economic growth, value-added and increased employment is, by and large, taken for granted. The question remains however whether this is really the case? At least on a regional level this is not reflected in those approximately 240 European (NUTS2) regions that there are comparable data for thus far.

Measuring economic progress and prosperity is difficult. Being aware of all its' pitfalls and restrictions, we will in this section nevertheless stick to the traditional method of using Gross Domestic Product as a proxy for economic success and general competitiveness, although other alternative measures, such as growth in jobs or migration, could equally well have been chosen.

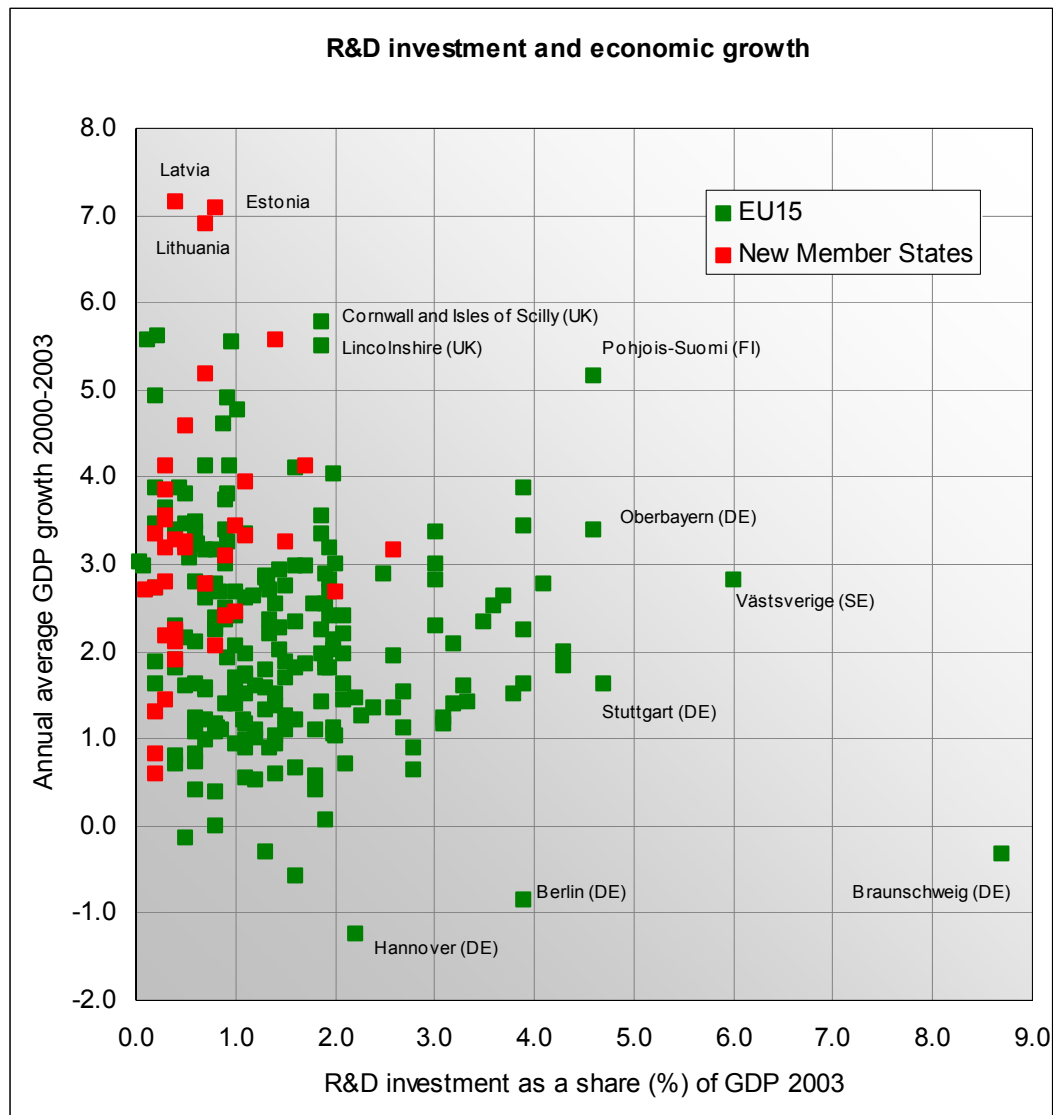
Large R&D investments do not necessarily yield higher growth rates

The Lisbon agenda set a target of an R&D investment rate of 3% (of GDP) to be reached by 2010. During 2000-2003 the un-weighted annual average economic growth rate for regions where R%D spending exceeds 3% of the GDP was 2.2% per year on average. However, for those regions where R&D spending was *below* this 3% target limit, the corresponding economic growth rate was higher (2.3% per year on average) than for the former group.

There is thus, on a European scale, little empirical evidence to suggest that high R&D investments yield better economic growth (Figure 13). In fact, the most R&D intensive region of Europe (Braunschweig in Germany) is the fourth slowest growing regional economy in the EU. Similarly, among the ten fastest growing regional economies, not a single one has an R&D rate exceeding 2% of the GDP, not to mention the 3% target limit.

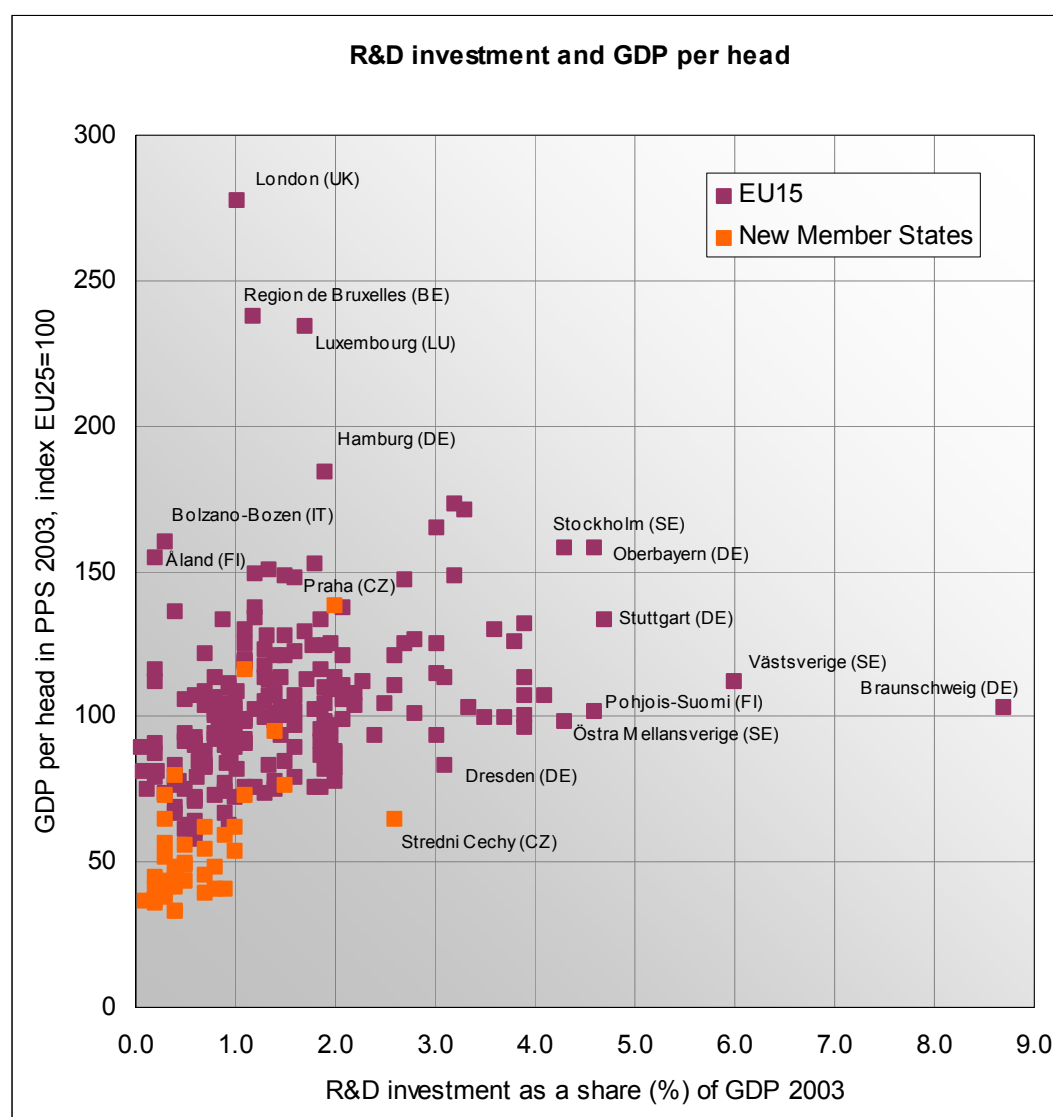
A slightly more recognisable pattern emerges when comparing R&D investments to economic strength, here measured as Gross Domestic Product per head in 2003 adjusted for purchasing power and indexed to the EU average. Particularly for the NMS there is a perceptible, albeit, weak relationship between R&D investment and economic strength. In these countries regions that invest – on an Eastern European scale – rather heavily, in research and development tend to have higher *per capita* production values than regions that invest less. For the Old MS this relationship is not as clear-cut, although there are very few heavily investing regions where GDP per head would be below the EU25 level (Figure 14).

Figure 13: R&D investment and economic growth in European NUTS 2 regions



Data source: Eurostat

Figure 14: R&D investment and economic strength in European NUTS 2 regions



Data source: Eurostat

Taken as a group, those regions that allocate more than 3% of their GDP to R&D have (an un-weighted) GDP per head some 21% above the EU25 average, whereas those that allocate less than 3% have a corresponding GDP per head 6% below the Union average. This fact alone however does not determine whether higher GDP is the result of increased spending or whether the relationship is the reverse.

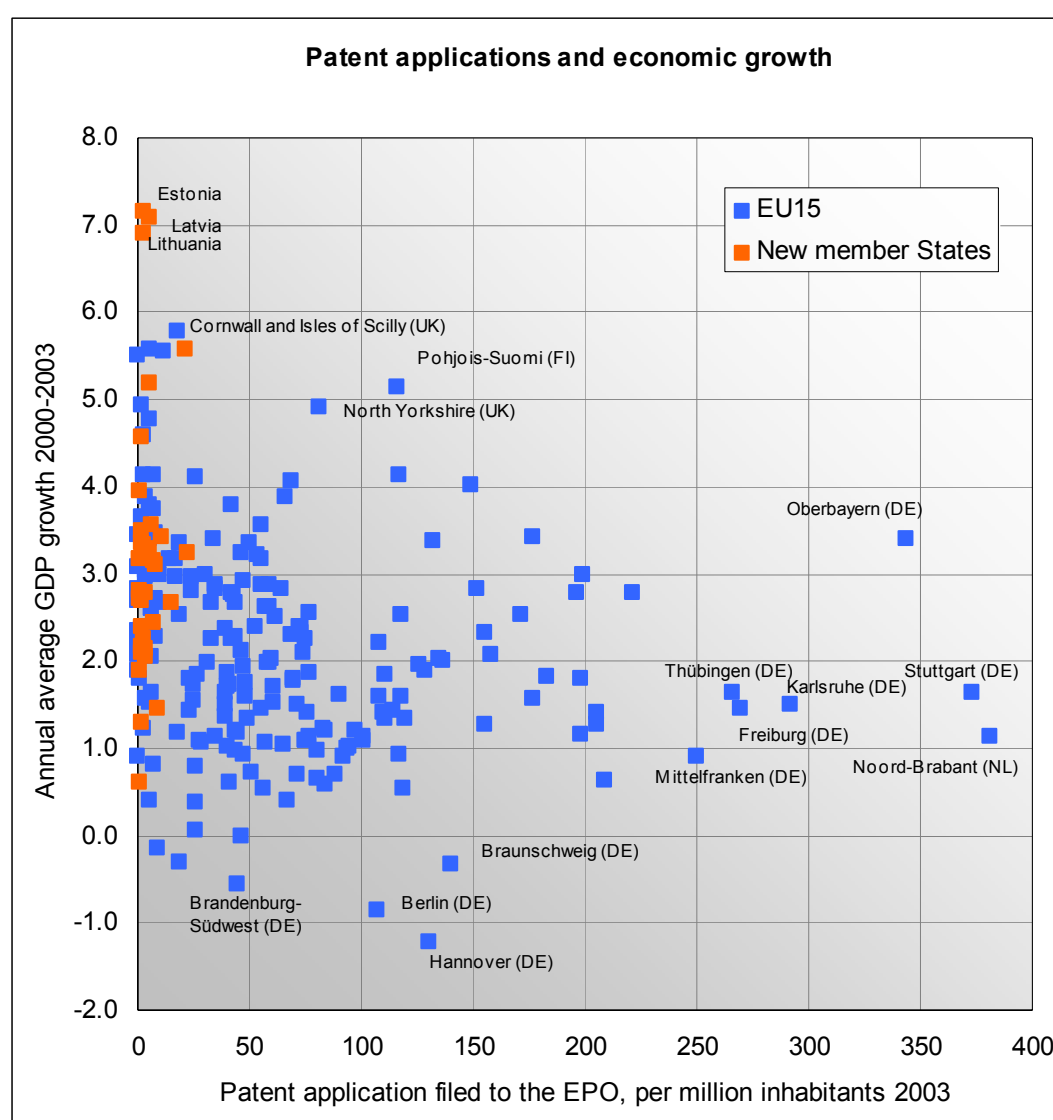
Innovative success no guarantee for economic progress

Linking a region's inventive activity to overall economic growth suggests that it is only one factor among others, e.g. structural ones, in adding economic value (Figure 15). On the one hand, the EU's fastest growing economies of Estonia, Latvia and Lithuania produce a minuscule number of applications to the EPO,

while on the other, economic growth in Europe's patenting "hot spots" in the Netherlands and Southern Germany, such as in Freiburg, Karlsruhe, Stuttgart (DE) and Noord-Brabant (NL), is at best comparatively modest. The German Oberbayern (Munich) region, with a high number of patents and rapid economic growth, makes for an obvious exception here.

Furthermore, variations in economic growth are huge in terms of different patent filing intensities in the EU15 as well as in the New Member States. While the economic growth of Pohjois-Suomi (FI) is at the top level, it is the opposite for Braunschweig, Berlin or Hanover (DE) who, in economic terms, are the worst performing in the EU in this context. The link between innovation measured in filed patents and economic growth thus remains difficult to establish both in a general and in a geographical sense.

Figure 15: Patent applications and economic growth in European NUTS 2 regions



Data source: Eurostat

Similar near-random patterns of correlation are also evident between e.g. employment in knowledge-intensive market services and economic growth.

Finer scale – better correlation

The examples above were all illustrated on a rough European scale. Shifting the focus to the local level reveals, at least for the Nordic countries, a substantial correlation between the knowledge-intensity of the economy and economic progress and strength. All capital regions and other large urban areas in the Nordic countries tend to have a higher than average R&D intensity, a larger knowledge-component in their economies, and stronger economies.

In addition, when moving beyond the metropolitan level, there are further indications that this is the case. This is exemplified in Table 2, where all 68 Nordic local labour markets with between 75 000 and 300 000 inhabitants are divided into two groups: those that have a university (29 cities) and those that do not (39 cities). All these cities are typically more or less peripheral, located as they are beyond the main urban agglomerations.

Table 2: Socio-economic performance of Nordic regional centres with, and without, universities

	Total population change 2000-05 Percent per year on average	Old age demographic dependency ratio ¹ 2005	Employment rate 2004	Employment change 2000-04 Percent per year on average
Nordic regional centres with university	0.5	23.7	70.4	0.8
Nordic regional centres without university	0.3	26.5	69.5	0.6

¹ Population aged 65+ as a share of population aged 15-64 years

Data source: national Statistical Institutes

In the former group of cities, the average population change has been nearly twice as high during the first years of this decade than in the second group. Moreover, the creation of new jobs has also been more vigorous in the former type of cities. There are also structural differences between the two groups: medium-sized university towns have a higher employment rate and a smaller share of elderly population than towns without universities. An introduction of additional variables, such as unemployment rate, educational level, income, etc. would most likely depict similar differences between the two groups of cities.

This brings about a tentative conclusion that, at least on a local level and scale, and at least in the Nordic countries, there seems to be a link between knowledge creation and socioeconomic progress and performance.

Missing links partly explained

The overall results for the regions of Europe taken as a group are controversial. A strict interpretation of the findings would indicate that it really does not pay to invest in increasing the knowledge component of the regional economy.

This is however most likely not the whole story. There are several issues that have been largely bypassed in the analysis above and which do each, at least partly, explain the apparent lack of correlation.

One tentative explanation for the surprisingly weak relationship between economic growth and R&D investment is that revenues from R&D related activities flow in a cyclical manner. In many branches, such as in pharmaceuticals, annual R&D costs are astronomical and do not normally yield revenues for decades, and if they do – not necessarily in the regions where the products were originally developed.

Moreover, especially regarding the densest R&D environments, internal financial transfers between different branches and departments of Multinational Corporations implies that a part of the “true” economic growth is not recorded in prevailing regional statistics.

In addition, different branches have differing return on investment (ROI) quotas for research expenditure. The aforementioned pharmaceutical industry or e.g. aeronautics provide good examples of a demand for high R&D input, whereas the opposite could hold true for e.g. several service industries. The regional mix of industry and regional economic structure therefore is likely to affect the outcome to a significant extent.

Similar factors are most likely also reflections of the weak link between patenting activity and economic growth. As indicated in the previous chapter, patenting on a European scale is largely in the hands of the manufacturing rather than the service industry, despite the latter accounting for a lion’s share of the European economy. Therefore also here the economic progress is most likely partly a reflection of the prevailing economic structure of the region.

Additionally, there is also the well-proven fact that the capability to capitalise on innovation differs substantially between different countries and regions. This is a particularly evident and thus a widely cited situation for example in Sweden, where R&D investments are the highest in the World but where the relative numbers of patent applications remain modest in light of the volume of investment when compared to e.g. the United States.

Moreover, pure academic research as such – unless transformed into commercial applications – yields little economic growth beyond the direct local effect on real wages, taxes and consumption. The fact that academic research results as such do not have clear and direct local or regional economic linkages does not however indicate that it has a less important economic role, merely that the empirical findings do not match our conception of existing reality. In many cases academic findings need to be filtered through other channels in order to end up as commercial products on the producer and consumer markets. This filtering can (and probably in most cases does) occur in other locations.

There is, finally, an additional aspect when it comes to the knowledge component of the regional economies. As indicated in the preamble and as exemplified throughout the previous section of this report, the effects of the “knowledge economy” impact rather more on developed than on less developed economies. Therefore, when economies mature, their future economic structure may be rather different from that which is currently foreseen.

To conclude, there does however seem to be a wide variety of courses for the regions of Europe to take. Each region has its own unique mix of endowments, not all of them necessarily having to do with the knowledge component alone,

and these endowments need to be harnessed for the overall economic good of the regions.

It is therefore both highly unlikely, and probably also undesirable, that each and every single region of Europe should compulsorily step into the knowledge-economy mould. Other pathways to prosperity are apparently also possible.

The fact remains though that there is obviously a clear need to further investigate the regional mechanisms of the knowledge economy on a pan-European scale and to highlight their links to overall economic growth so that the prevailing "one size fits all" image of the desirable paths to economic prosperity could be painted with a slightly more diversified colour palette.

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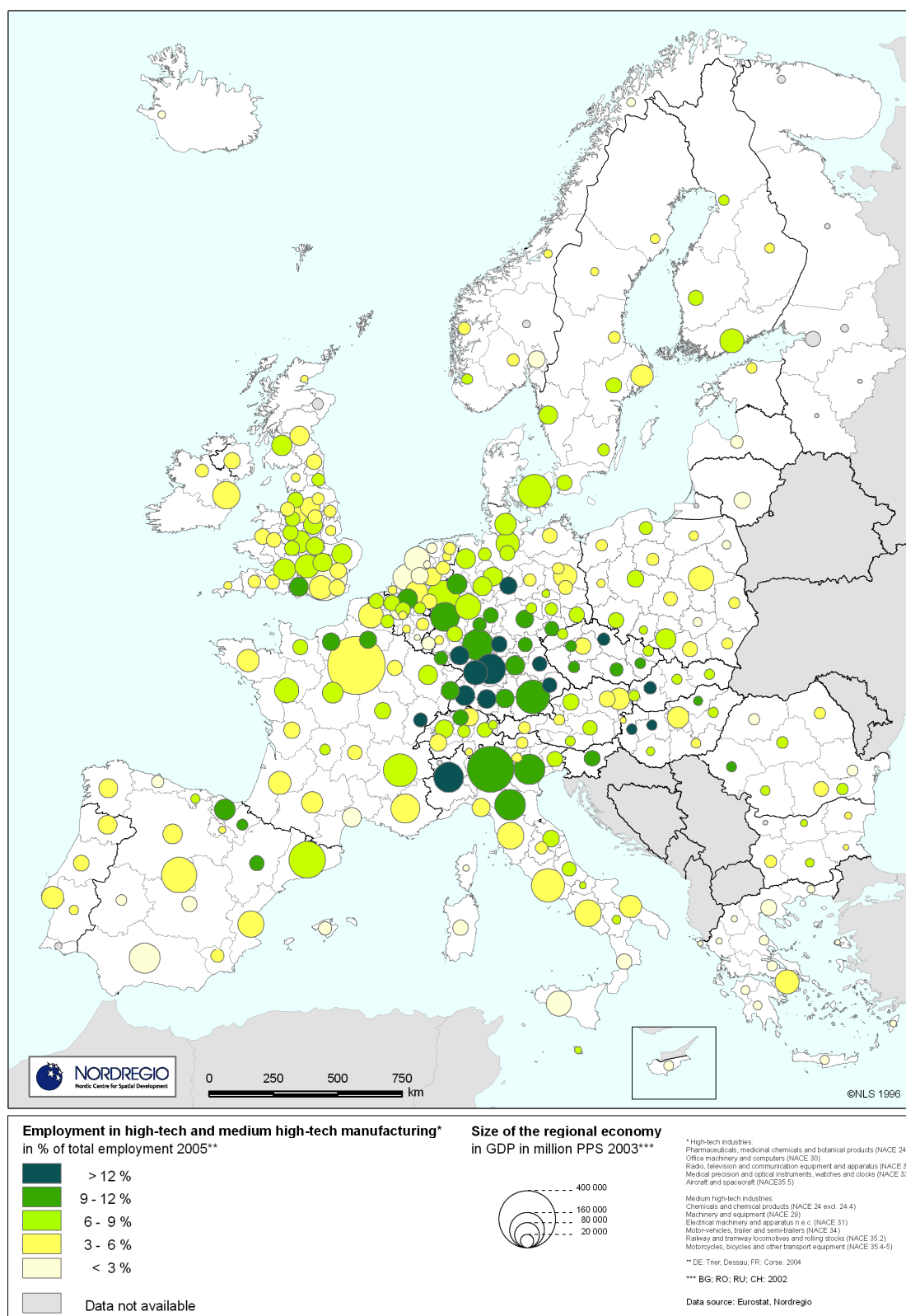
Annexes:

Annex 1: R&D expenditure by source of funding 2003

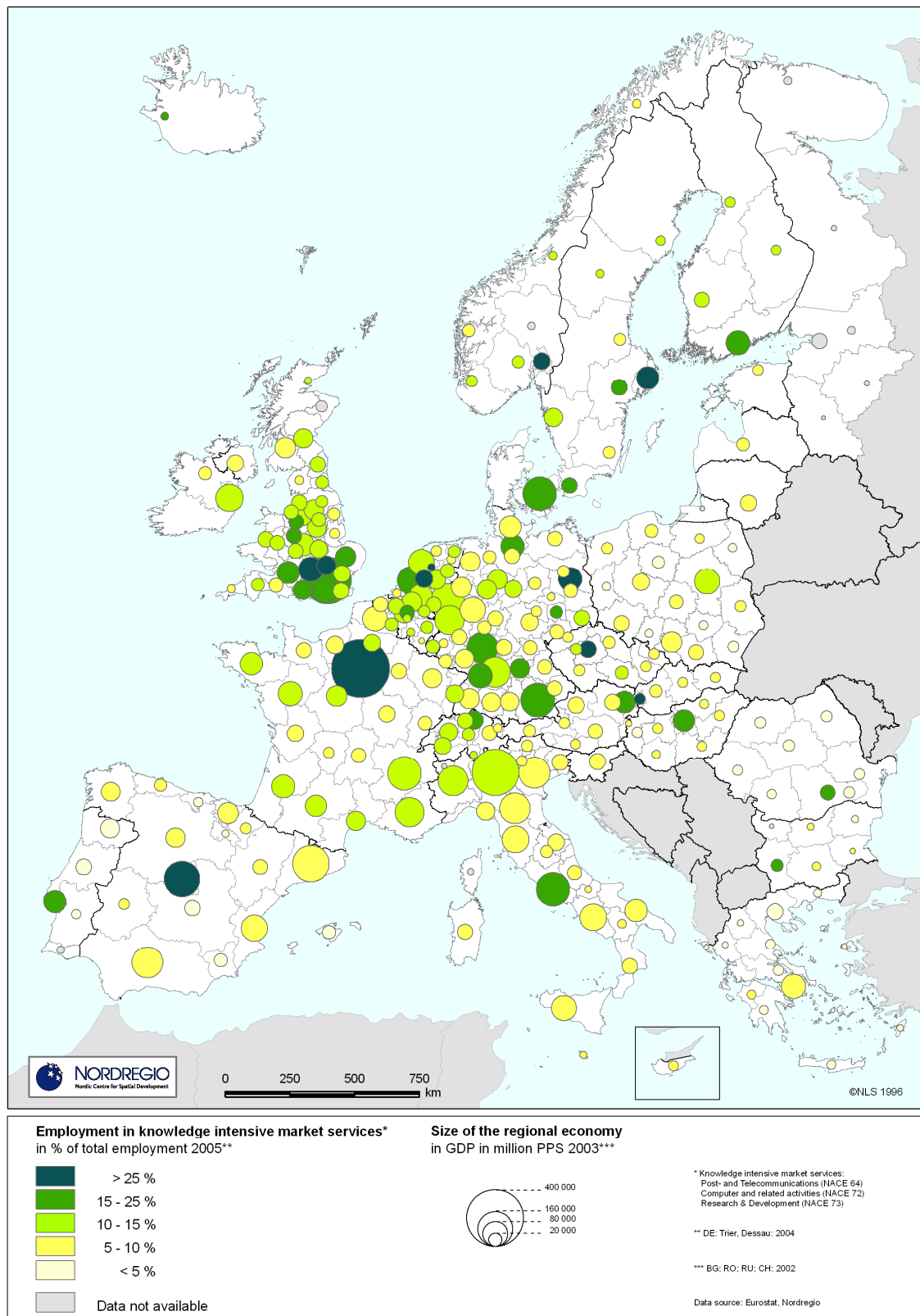


EU25, JP, AT, SI: Eurostat estimates; US, LU: provisional
Data source: Eurostat, OECD

Annex 2: Employment in high and medium high-tech manufacturing 2005



Annex 3: Employment in knowledge-intensive market services 2005



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