15

Science, technology and innovation

Introduction

Based on a number of data sources available at Eurostat, this chapter presents statistical data and indicators designed to illustrate the trends and structure of science, technology and innovation (STI) in European regions and compare them to other regions. The domains covered are research and development (R & D), patents, high technology and human resources in science and technology (HRST). More regional indicators on science, technology and innovation are available on the Eurostat website under 'Science and technology'.

Main statistical findings

Research and development

Twenty-five of the 260 EU regions shown on Map 15.1 spend the equivalent of more than 3 % of their GDP on R & D. These regions exceed the R & D intensity target set by the Barcelona Council in 2002 and maintained in the Europe 2020 strategy.

A cluster of four research-intensive regions can be found in south-western Germany: Stuttgart (5.83 %), Karlsruhe (3.75 %), Tubingen (3.79 %) and Darmstadt (3.11 %). These regions are also very important in absolute terms, as together they generate around 8 % of the total R & D expenditure in the EU. Another leading region in terms of R & D is Oberbayern (4.29 %), to the east of the four-region cluster, which contributes another 3 % to the EU total. Further north, Braunschweig (6.75 %), in the middle of Germany, is the most R & D-intensive region on the map. East of Braunschweig are two more major R & D regions: Dresden (4.08 %) and Berlin (3.31 %).

The two most R & D-intensive regions in the UK are East Anglia (5.93 %), which is the second most R & D-intensive region on the map, and Cheshire in North West England (5.7 %). Together these regions generate around 2 % of the EU total. Other R & D-intensive regions in the UK are Essex (3.24 %), Berkshire, Buckinghamshire and Oxfordshire (3.24 %) and North Eastern Scotland (3.18 %).

Eight of the most R & D-intensive regions are located in the Nordic countries. These regions are, starting from the south, Hovedstaden (the region surrounding the capital København) in Denmark (5.1 %), Sydsverige (4.75 %), Västsverige (3.72 %), Östra Mellansverige (3.74 %) and Stockholm (4.03 %) in Sweden and Etelä-Suomi (3.66 %), Länsi-Suomi (3.91 %) and Pohjois-Suomi (5.87 %) in Finland, the last of which is the third most R & D-intensive region on the map.

In France ([1]), the most R & D-intensive region is Midi-Pyrénées (4.15 %), just north of the Iberian Peninsula. In absolute terms, Île de France (3.11 %), which includes the French capital, is among the leading regions in the EU. Two more regions with relatively high R & D intensity are located in Austria: Steiermark (3.74 %) and Wien (3.61 %).

Map 15.2 provides an overview of the regional distribution of the share of researchers in total employment (measured in headcount). Researchers are the core category directly employed on R & D activities. They are defined as 'professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and in the management of the projects concerned'. The highest share of researchers out of all persons employed (more than 1.8 %) was found in 25 of the regions shown on Map 15.2. With six regions in this group of front-runners, the United Kingdom was the leading country, followed by Germany with five regions, Finland with three and Sweden and Norway with two each. Austria, Belgium, the Czech Republic, France, Portugal, Slovakia and Iceland each had one top region.

The share, or intensity, of researchers ranged from 1.2 % to 1.8 % in 40 European regions. Again, most were located in the United Kingdom (11), followed by another nine regions in Germany. In the vast majority of European regions, the share of researchers did not exceed 0.6 % of all persons employed. Twenty EU Member States and Norway reported at least one region with an intensity of researchers below 0.6 %.

Looking at national differences, the spread between the regions with the highest and lowest proportions of researchers in total employment was particularly wide in the United Kingdom (4.47 percentage points between North Eastern Scotland and Highlands and Islands) and the Czech Republic (2.91 percentage points between Praha and Severozapad). Ireland had the narrowest regional disparities in intensity of researchers (0.16 percentage points).

Human resources in science and technology

Investment in research, development, education and skills is a key policy area for the European Union, as they are essential to economic growth and to developing a knowledge-based 'smarter' economy. This has led to an increasing interest in the role and measurement of skills of the human resources in science and technology. It is therefore extremely important for policymakers at regional level (and also at EU and national levels) to analyse the stock of highly qualified people who are actively participating in science and technology activities and technological innovation. One way to measure the concentration of highly

([1]) Data for France is from 2004.

qualified people in the regions is to look at human resources in science and technology (HRST). HRST includes persons who have completed tertiary (i.e. university) education (HRSTE) and/or are employed in a science and technology occupation (HRSTO). The stock of HRSTO can be used as an indicator of development of the knowledge-based economy in the EU.

As Map 15.3 shows, HRSTO are mostly concentrated in urban regions, in particular around the capitals. In 2009, 11 of the 25 leading regions were capital regions, where there is often a high concentration of highly qualified jobs, for example due to the presence of head offices of companies and government institutions. Capitals are often big cities with many higher education facilities and a high number of highly educated people. This makes these and the surrounding regions attractive places to open science and technology-related businesses. At the same time, highly skilled people are often attracted to larger cities, as they are more likely to find a job that meets their requirements in a region where there are many companies.

This urban concentration of human resources employed in science and technology can also be seen by looking at two of the three large regional clusters with shares of HRSTO exceeding 35 % in 2009. The first of these clusters stretches from Switzerland into central and south-eastern Germany. In general, the regions in this cluster are very densely populated. This also applies to the regions in the second distinct cluster, which spans the Benelux countries and the western border regions of Germany. The third cluster is in the Scandinavian countries, where regions — apart from the capital regions — are very sparsely populated. The regions with the second, third and fifth highest shares of HRSTO are also in Scandinavia: Stockholm in Sweden (47.4 %), Oslo og Akershus in Norway (46.2 %) and Hovedstaden (København) in Denmark (45.1 %). The highest share, however, is reported in Praha (Czech Republic), where 50.6 % of the labour force are HRSTO.

Based on R & D intensity, sectors of economic activity can be subdivided into more specific subsectors for the purpose of analysing employment in science and technology. For manufacturing industries, four groups have been identified, depending on the level of R & D intensity: high, medium-high, medium-low and low-technology sectors. Services are classified into knowledge-intensive (KIS) and less knowledge-intensive services.

High-tech knowledge-intensive services and high-tech manufacturing are the two subsectors of greatest importance for science and technology in terms of generating relatively high added value, providing new jobs and contributing to competitive growth. Consequently, these two sectors are often analysed jointly as high-tech sectors. The NACE Rev. 2 classification defines high-tech knowledge-intensive services as including motion picture, video and television programme production, sound recording and music publishing activities, programming and broadcasting, telecommunications, computer programming and related activities, information service activities and research and development.

High-tech manufacturing covers the manufacture of pharmaceutical products and pharmaceutical preparations and of computers and electronic and optical products.

The service sector employed around 69 % of the labour force in the EU in 2009, but only 2.6 % of the labour force was employed in high-tech knowledge-intensive services. The manufacturing sector employed 16.2 %, but only 1.1 % of the labour force was employed in high-tech manufacturing.

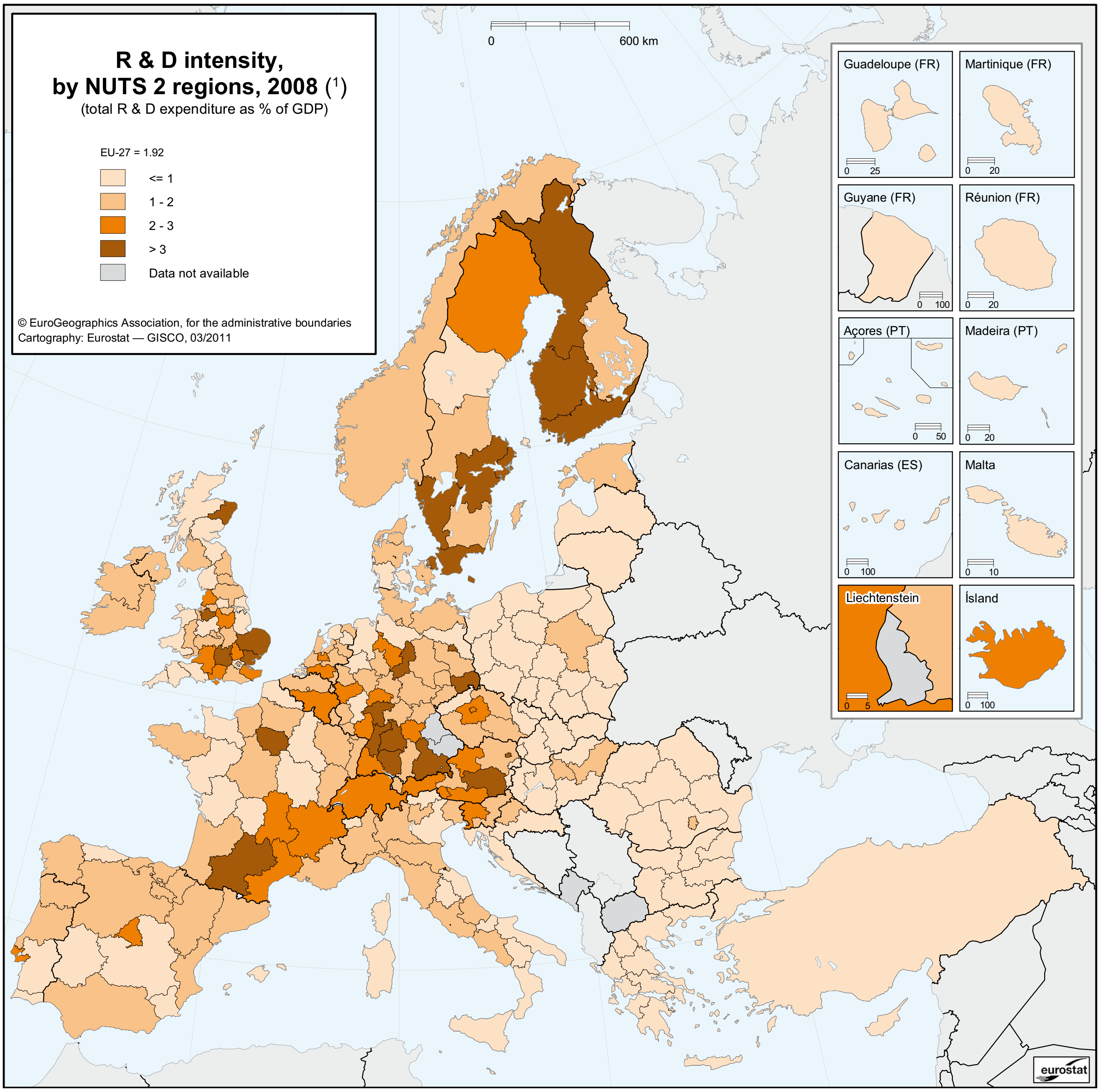
Figure 15.1 shows the regional disparities in high-tech sectors (by NACE Rev. 2) as a share of total employment. This figure plots the national average for each country and the regions with the lowest and highest shares of employment in high-tech sectors. At EU level, high-tech sectors (high-tech manufacturing and high-tech KIS) represented 3.7 % of total employment in 2009 with two thirds employed in high-tech knowledge-intensive services and one third occupied in high-tech manufacturing.

As the figure shows, the national and regional highest and lowest shares vary significantly from one country to another and significant disparities can be observed at regional level.

Regarding national averages, 17 out of the 32 observed countries registered values higher than the EU-27 average (3.7 %) with over 5.0 % in Denmark, Malta, Finland, Sweden, Iceland and Switzerland. On the other range of the scale, the lowest national shares of high-tech sectors in total employment below 2.5 % were registered in Greece, Cyprus, Latvia, Lithuania, Portugal, Romania and Turkey. Six European countries (Estonia, Cyprus, Latvia, Lithuania, Luxembourg and Malta) and Iceland are classified at NUTS level 1.

At regional level, urban regions, especially capital regions or regions situated close to capitals, often exhibit high shares of employment in high-tech sectors. Berkshire, Buckinghamshire and Oxfordshire (United Kingdom), situated in close proximity to London, stood out with approximately 10.0 % of the labour force in high-tech sectors. No region exceeded this share, the next closest being Comunidad de Madrid (Spain) with 9.3 %, Hovedstaden (Denmark) with 9.2 % and Province Brabant Wallon (Belgium) (9.1 %). The lowest shares of less than 1 % were registered in Trabzon (Turkey), Sud - Muntenia (Romania) and Centro (Portugal). Spain, the United Kingdom, Denmark, Belgium and Sweden are the countries with the highest regional employment, while Italy and France showed the biggest regional disparities when measured by the ratio of highest share to the lowest share. The lowest discrepancies in employment between regions were observed in Ireland, Greece, the Netherlands, Croatia and Turkey.

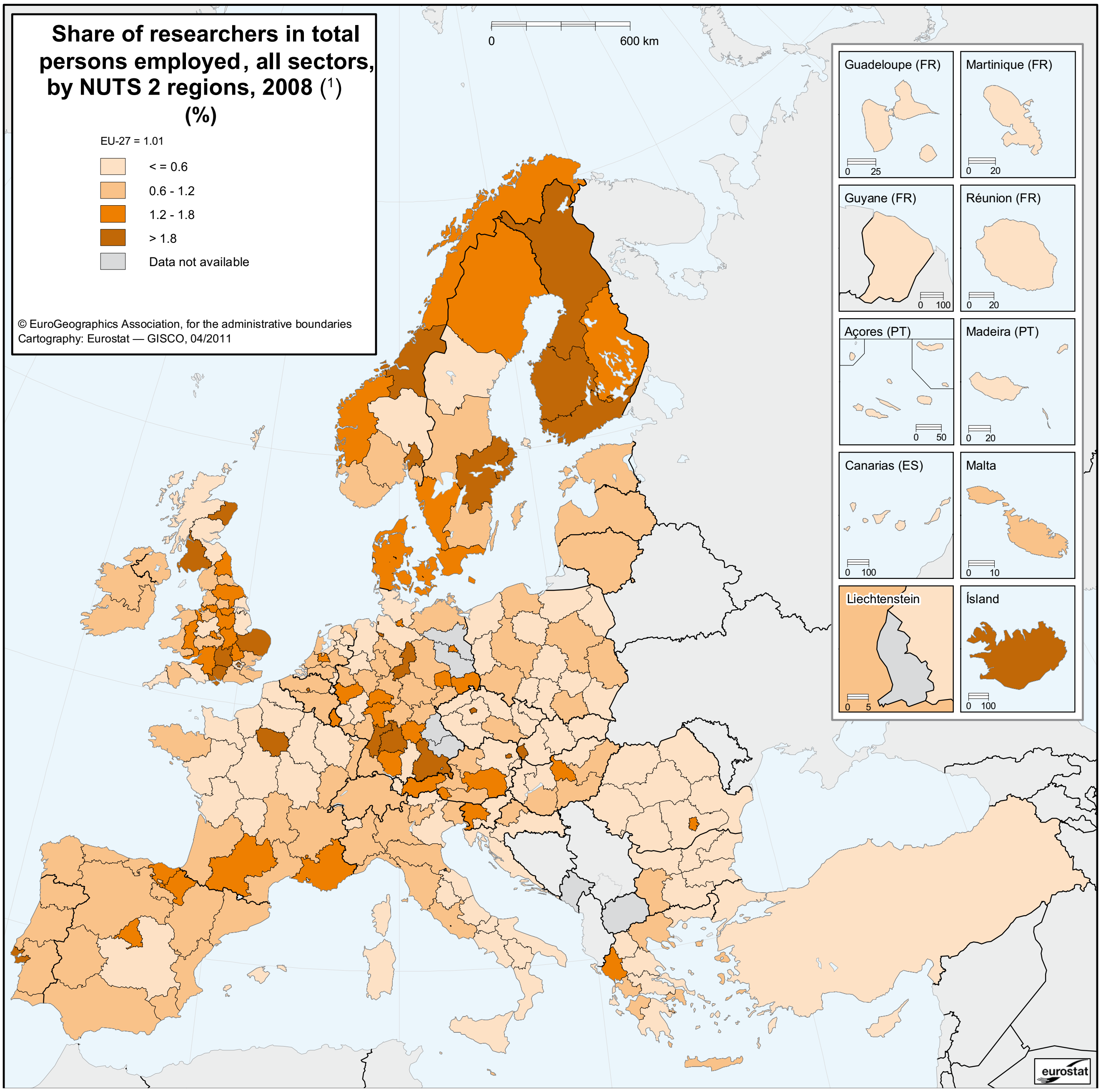
Map 15.1: R & D intensity, by NUTS 2 regions, 2008 (1)
(total R & D expenditure as % of GDP)



(1) EU-27, Eurostat estimate; Belgium, Denmark, Germany, Ireland, Netherlands, Austria and Sweden, 2007; Greece, 2005; France, 2004; Belgium, Départements d'outre-mer (France) and Croatia, by NUTS 1 regions; Norway, Switzerland and Turkey, national level; Niederbayern and Oberpfalz (Germany), confidential data; Estonia, Ireland, Luxembourg and Malta, provisional data; Netherlands, estimate; Sweden, in some cases researchers are allocated to the head office; Denmark, break in series with previous year for which data is available.

Source: Eurostat (online data code: rd_e_gerdreg).

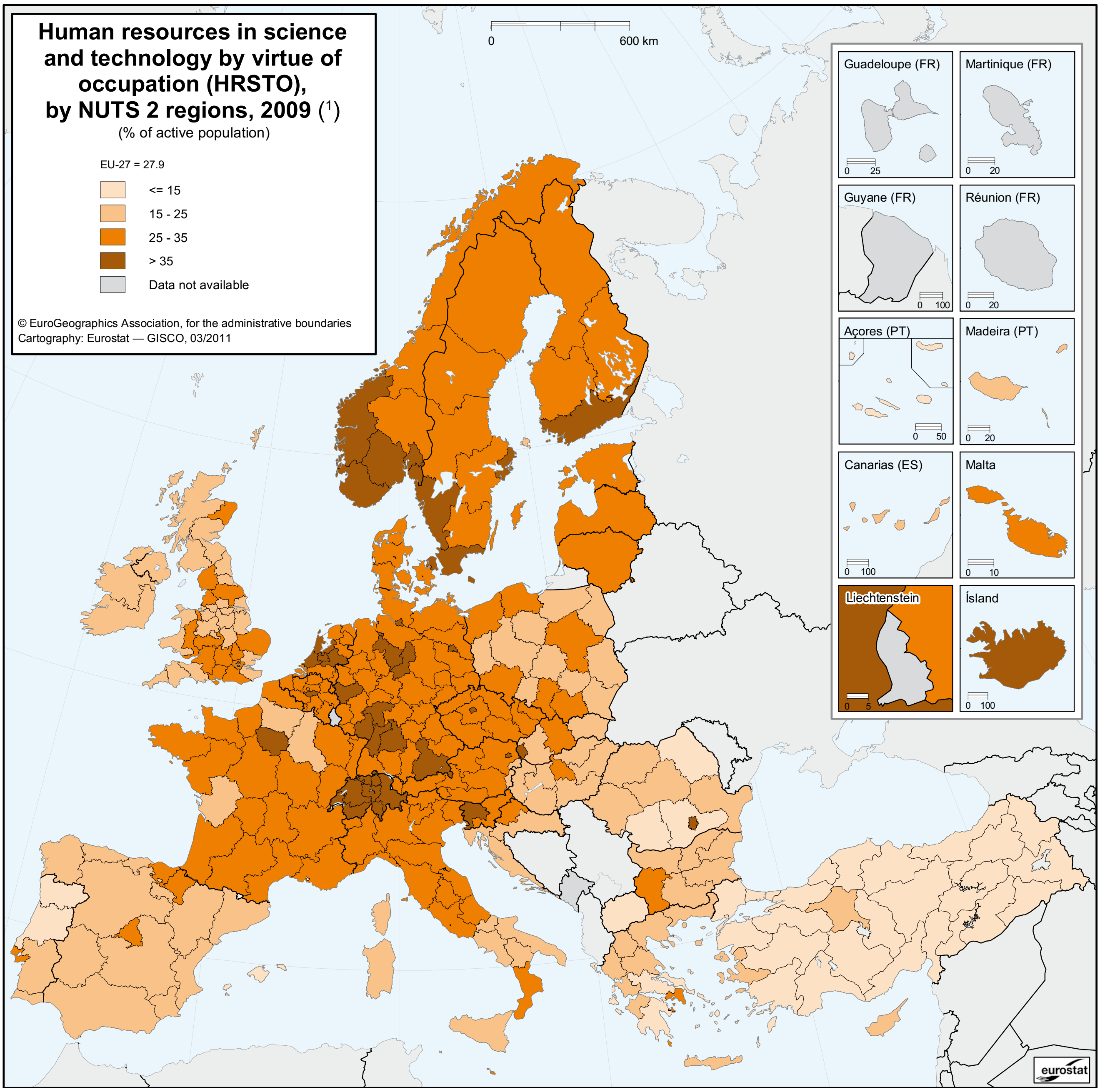
Map 15.2 Share of researchers in total persons employed, all sectors, by NUTS 2 regions, 2008 (1) (%)



(1) EU-27, Eurostat estimate; Belgium, Germany, Ireland, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Austria, Sweden and United Kingdom, 2007; Greece, 2005; France, 2001; Denmark, Switzerland and Turkey, national level; Belgium, Départements d'outre-mer (France) , by NUTS 1 regions; Estonia, Luxembourg, Netherlands and United Kingdom, national estimates; Ireland, provisional data; Niederbayern, Oberpfalz, Brandenburg - Nordost and Brandenburg - Südwest (Germany), confidential data; Sweden, in some cases researchers are allocated to the head office.

Source: Eurostat (online data code: rd_p_persreg).

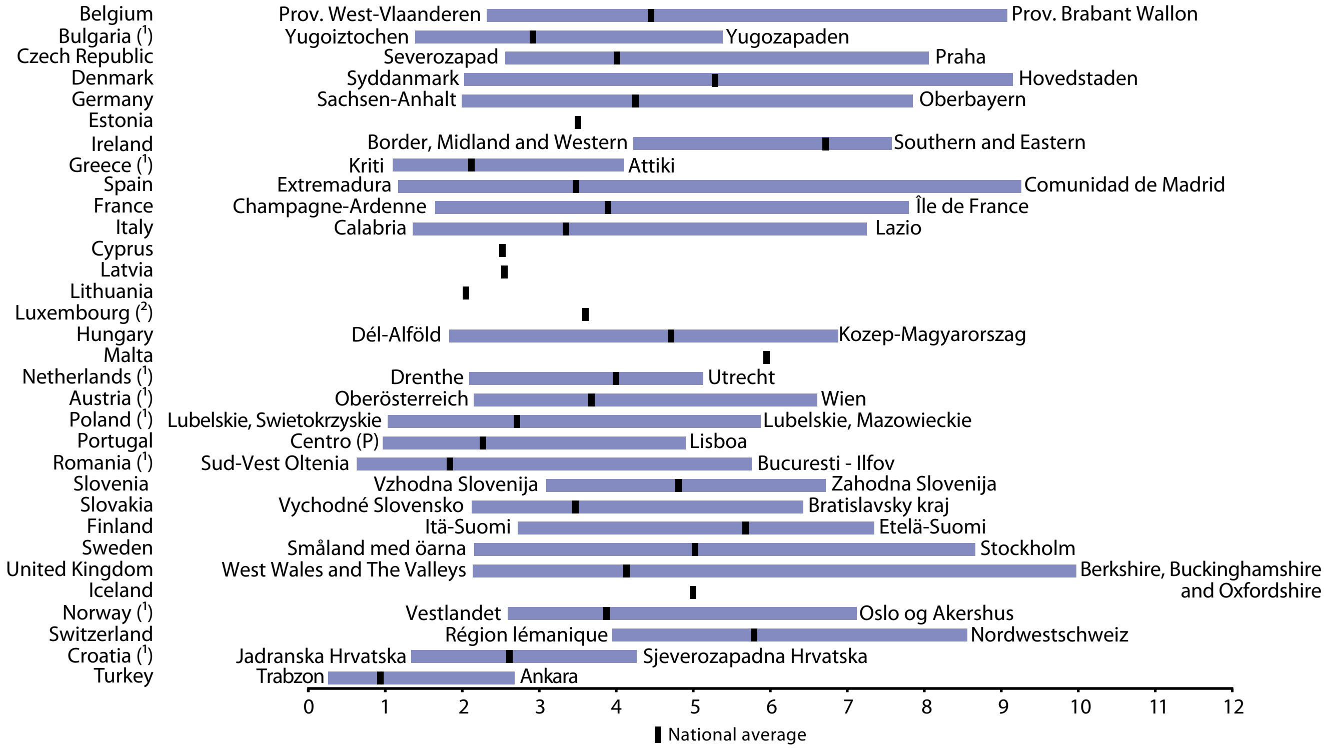
Map 15.3: Human resources in science and technology by virtue of occupation (HRSTO), by NUTS 2 regions, 2009 ([1])
(% of active population)



([1]) Corse (France) and Åland (Finland), data lack reliability due to reduced sample size, but publishable.

Source: Eurostat (online data code: hrst_st_rcat).

Figure 15.1: Employment in high-tech sectors as a share of total employment, highest and lowest NUTS 2 region within each country, 2009 (1)



(1) High-tech sectors = high-technology manufacturing plus high-tech knowledge-intensive services (KIS). Data lack reliability due to small sample size, but are publishable in region with the smallest share in Bulgaria, Greece, Netherlands, Austria, Poland, Romania, Norway and Croatia.
(2) Luxembourg, 2008.

Source: Eurostat (online data code: htec_emp_reg2).

Patents

In today's knowledge-based economy, new knowledge creation and innovation are increasingly important for sustaining and improving the economic welfare and growth of regions and countries. Research and development activities as well as innovation are therefore at the heart of many regional policies, including the Europe 2020 strategy for smart growth. Patent data are an important source of information on the location of technological inventions, and on the organisations and research institutions involved. Research has shown that innovative activities, as measured by patent counts, tend to cluster geographically in a limited number of regions. This is especially true for the high-tech industries.

Regional patent statistics are based on patent applications to the European Patent Office (EPO). Based on the address of the inventors, patents can be linked to a region, as defined in the nomenclature of territorial units for statistics (NUTS). Regional patent statistics have several advantages. First, they give a comparison of the technological performance of regions in Europe. In addition, the trend in the technological performance of regions can be monitored over time. Finally, they give detailed information on the technological content of patent filings that allow investigation of specific technology fields. However, there are disadvantages to using patents as indicators of technological performance as not all inventions are patented, patent propensities vary across industries and firms and patented inventions vary in technical and economic value.

Regional patents statistics for EPO patent applications build on information from addresses of inventors. Eurostat has developed a methodology that allows postcode and city information to be parsed out from the address fields of inventors and allocates these addresses based on the postcode and/or city name to the corresponding regions as defined by NUTS. Different quality control procedures are built into the allocation process to prevent misallocations from errors in postcodes and city names, historical changes in postal code systems and city homonyms.

In the following figures, the technological performance of regions is calculated as the number patents per population at NUTS level 3 regions in Europe. Reporting technology figures in relation to population allows a comparison to be made of regions of different sizes. However, it also implies that, in some cases, less densely populated regions or regions with a comparatively low number of inhabitants may rank relatively high in terms of patents per population, even though the region does not perform that well in terms of absolute number of patents. Furthermore, patents have been allocated to regions based on inventor addresses, which may not always tally with the place (region) of invention. Indeed, inventors do not necessarily live in the same region as the one in which they work. The bias introduced by the phenomenon of commuting between home and work places is likely to increase when smaller geographical units (NUTS 3 regions) are used.

Map 15.4 shows that technological activity is very much concentrated in the centre of Europe, with the region of Zuidoost-Noord-Brabant in the Netherlands ranking highest in terms of patents per population (more than 2 000 patents per million population), followed by the regions of Erlangen Kreisfreie Stadt, Erlangen-Höchstadt, Heidenheim, Ludwigsburg and Starnberg (over 1 000 patents per million population) and many other German regions (more than 500 patents per million population). The regions of Pirkanmaa in Finland and Rheintal-Bodenseegebiet in Austria count more than 500 patents per million inhabitants. Important technological activities (more than 250 patents per million inhabitants) are also found in some regions in France, Sweden, Denmark, Italy and Belgium, and others in Austria, Finland and Germany.

In the field of ICT (Map 15.5), the regions of Zuidoost-Noord-Brabant in the Netherlands and Erlangen Kreisfreie Stadt in Germany are the top regions in terms of the number of patents per population (approximately 1 000 patents per million population). The regions of Erlangen-Höchstadt, München Landkreis, Starnberg and Schwarzwald-Baar-Kreis in Germany count more than 400 patents per million population. In the other European countries, the regions of Pirkanmaa, Uusimaa and Pohjois-Pohjanmaa (Finland), Isère (France) and Skåne län (Sweden) can be considered as the leading regions in ICT patenting (more than 200 patents per million population).

Figure 15.2 shows large differences between the top regions of countries in terms of patents per population in the field of biotechnology. With more than 180 biotech patents per million population, the region of Weilheim-Schongau in Germany is by far the top region in Europe. The region of Zuidoost-Noord-Brabant in the Netherlands, Uppsala län in Sweden, the region of Nivelles in Belgium and Hovedstaden in Denmark are top regions in their country in terms of biotechnology patents per population and also among the top-performing regions in Europe in the field of biotechnology (more than 50 patents per million population). Figure 15.2 also illustrates that the average technological performance of regions differs greatly by country. Germany, Denmark, Sweden and the Netherlands, and to a lesser extent Belgium and Austria, have the highest average number of biotech patents per population.

Data sources and availability

The data in the maps and tables in this chapter are, wherever possible, by NUTS 2 and NUTS 3 regions. Data are extracted from the 'Science, technology and innovation' domain and, more specifically, from the subdomains 'Research and development', 'Human resources in science and technology', 'High technology industries and knowledge-intensive services' and 'Patents'.

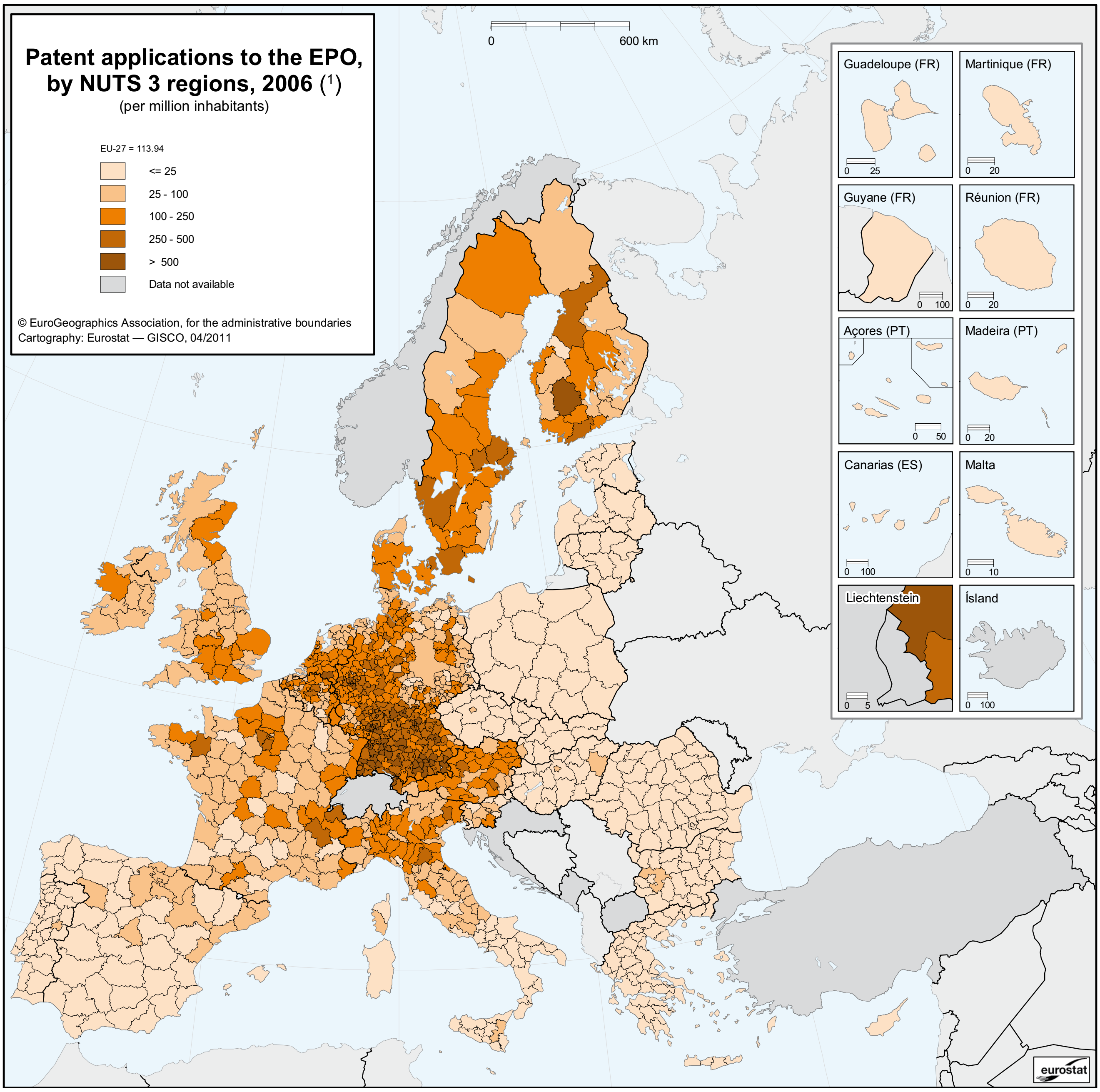
Eurostat collects **statistics on research and development** under the legal requirements of Commission Regulation (EC) No 753/2004, which determines the dataset, breakdowns, frequency and transmission delays. The methodology for national R & D statistics is laid down in the *Frascati manual*: *proposed standard practice for surveys on research and experimental development* (OECD 2002), which is also used by many non-European countries.

Statistics on **human resources in science and technology (HRST)** are compiled annually, based on microdata extracted from the EU Labour Force Survey (EU LFS). The basic methodology for these statistics is laid down in the *Canberra manual*, which lists all the HRST concepts.

Data on **high-technology industries and knowledge-intensive services** are compiled annually, based on data collected from a number of official sources (EU LFS, structural business statistics, etc.). The high-technology employment aggregates are defined in terms of R & D intensity, calculated as the ratio of R & D expenditure on the economic activity to its value added, and based on the statistical classification of economic activities in the European Community (NACE). The NACE was revised from Rev. 1.1 to Rev. 2, which led to changes in the high-technology and knowledge-intensive sectors. The statistics in this chapter are based on NACE Rev. 2.

Data on **patent applications to the EPO** are compiled on the basis of microdata from the European Patent Office (EPO). The patent data reported include patent applications filed at the EPO during the reference year, classified by the inventor's region of residence and in accordance with the international patents classification of applications. Patent data are regionalised using procedures linking postcodes and/or place names to NUTS 2 and 3 regions. Patent statistics published by Eurostat are almost exclusively based on the EPO Worldwide Statistical Patent Database, Patstat, developed by the EPO in 2005, using its patent data collection and its knowledge of patent data. The data are largely taken from the EPO's master bibliographic database, DocDB, which is also known as the EPO Patent Information Resource. It includes bibliographic details on patents filed at more then 90 patent offices worldwide and contains more than 50 million documents. It covers a large number

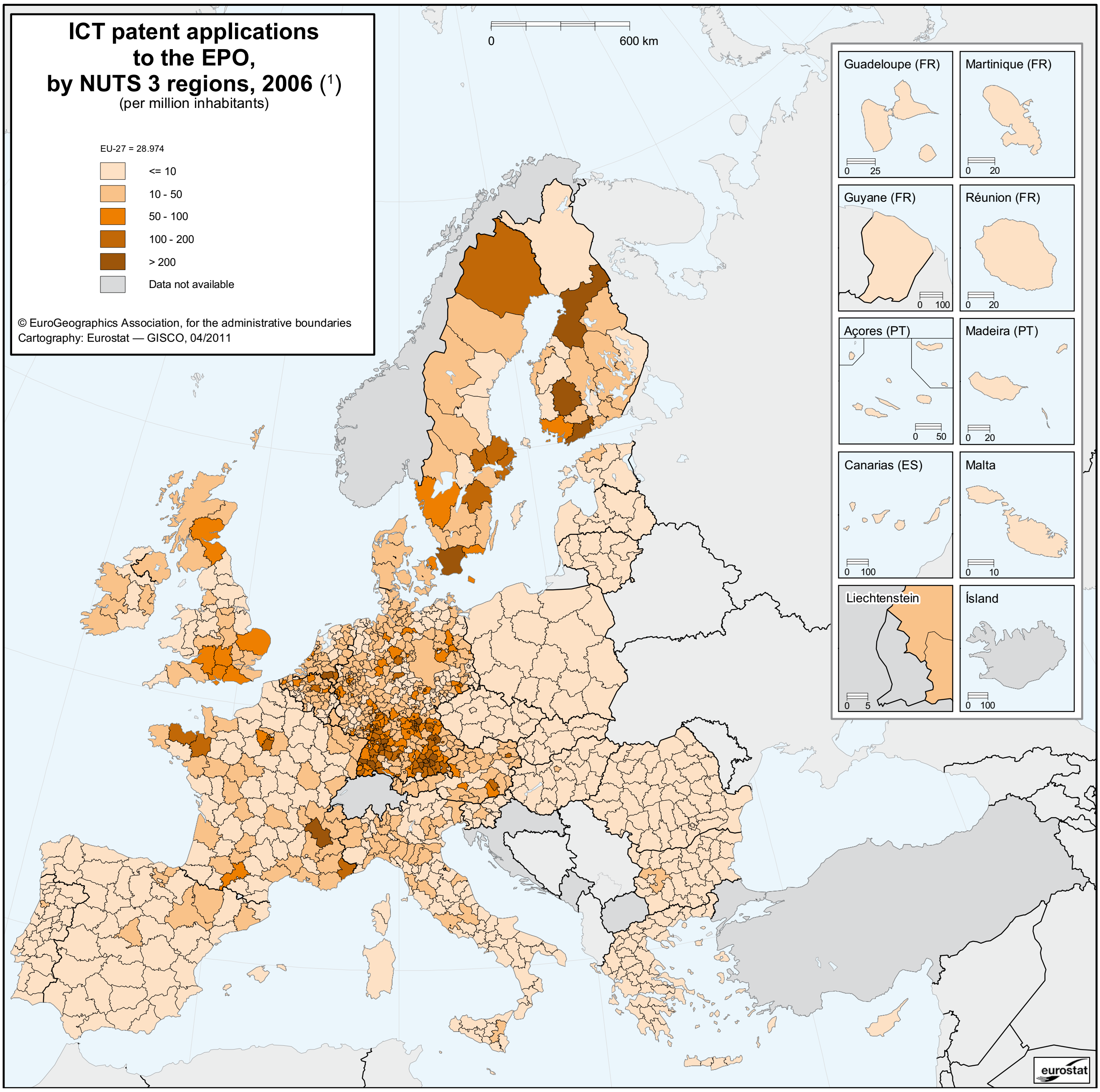
Map 15.4: Patent applications to the EPO, by NUTS 3 regions, 2006 ([1])
(per million inhabitants)



([1]) Ireland, Greece and Finland, population data for 2007; London (United Kingdom), by NUTS 1 region; Denmark, Sachsen-Anhalt (Germany), Illes Balears and Canarias (Spain), Sardegna (Italy), Poland and United Kingdom, by NUTS 2 regions.

Source: Eurostat (online data code: pat_ep_rtot).

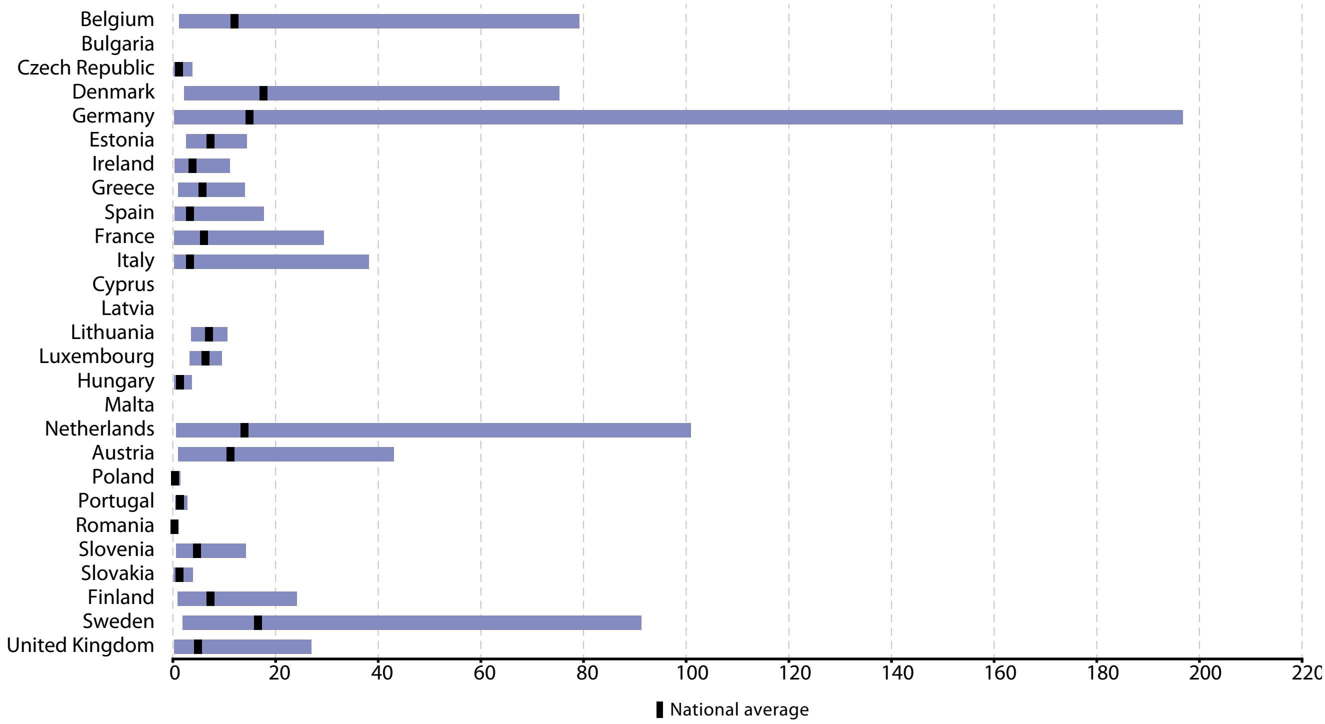
Map 15.5: ICT patent applications to the EPO, by NUTS 3 regions, 2006 ([1])
(per million inhabitants)



([1]) Ireland, Greece and Finland, population data for 2007; London (United Kingdom), by NUTS 1 region; Denmark, Sachsen-Anhalt (Germany), Illes Balears and Canarias (Spain), Sardegna (Italy), Poland and United Kingdom, by NUTS 2 regions.

Source: Eurostat (online data code: pat_ep_rtot).

Figure 15.2: Biotechnology patent application to the EPO, highest and lowest region within each country, by NUTS 3 regions, 2006 ([1])
(per million inhabitants)



([1]) Ireland, Greece and Finland, population data for 2007; Denmark, Poland and United Kingdom, by NUTS 2 regions.
Source: Eurostat (online data code: pat_ep_rbio).

of fields included in patent documents, such as application details (claimed priorities, application and publication), technology categories, inventors and applicants, title and abstract, patent citations and non-patent literature.

Context

Since the Lisbon Council in March 2000 and the Barcelona Council in 2002, the European Union and the Member States have spared no effort in turning the EU into 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' by 2010.

These efforts — based on the Lisbon strategy — highlighted the importance of R & D and innovation in the EU. To follow up, the 2005 initiative on 'Working together for growth and jobs' gave new momentum and placed science, technology and innovation back at the heart of EU national and regional policies to deliver targeted action on 'Knowledge and innovation for growth'.

The EU and the Member States fully recognised that science, technology and innovation, together with high-quality education and lifelong learning, are essential to turn Europe into a leading knowledge-based society, thus creating the right conditions for long-term prosperity. To achieve this, building the European research area (ERA) is at the top of the political agenda.

As the Lisbon strategy expired and the recent economic crisis hit, a new strategy for the EU was called for. On the basis of the conclusions of the Spring European Council of March 2010 and of the Commission communication on 'Europe 2020', the European Council agreed on the main pillars of this new strategy, which was formally adopted in 2010. Supported by seven flagship initiatives, Europe 2020 puts forward three mutually reinforcing priorities: **smart growth** (developing an economy based on knowledge and innovation); **sustainable growth** (promoting a more resource-efficient, greener and more competitive economy); and **inclusive growth** (fostering a high-employment economy delivering social and territorial cohesion).

The European Commission's 'Innovation Union' is a flagship initiative under the Europe 2020 strategy. It sets out a strategic approach to innovation, backed at the highest political level. The Innovation Union will focus Europe's efforts — and cooperation with third countries — on challenges like climate change, energy and food security, health and an ageing population. It will use public-sector intervention to stimulate the private sector and to remove bottlenecks that stop ideas reaching the market. These include lack of finance, fragmented research systems and markets, under-use of public procurement for innovation and slow standard-setting.

Part of the EU's growth potential has been seriously undermined by the economic crisis, which changed the overall perspective dramatically and was largely responsible for steering some European regions off the course to growth and economic sustainability. Overall, the effects of the crisis make the challenges that existed before the crisis, such as globalisation, demographic ageing, lagging productivity and climate change, much harder to handle. This underlines the need for meaningful indicators on science, technology and innovation. Such indicators are of paramount importance for informing policymakers on where European regions stand and can help them take the necessary measures to bring all regions back on the path to more knowledge and growth. This information also helps to draw a clear comparative picture as to how regions are evolving both at European level and worldwide.

Based on the statistics and indicators, this publication highlights the European regions that are performing well in research and development activities and those that need support.

Data on high-tech industries and knowledge-intensive services, patents and human resources in science and technology were also used extensively to complete the regional picture.