CHAPTER 2

Thematic diversity: specialisation at national and regional level

HIGHLIGHTS

In general, European countries and regions may need to identify and define areas where they need to focus their scarce scientific and technological resources in order to achieve critical mass, obtain meaningful results and develop a competitive advantage. The process of building a competitive advantage in research and innovation is a complex strategic process that needs to build on existing strengths, create networks and be linked to broader socio-economic political goals. This process is not exempt from risks (e.g. 'picking up loser' or being driven to technological lock-in strategies), and requires a great deal of data for analysis and policy reflection. Specialisation indexes show the comparative advantage of one system and the dynamics of one country or region.

Based on these indexes, the EU, as the United States, presents overall a fairly diversified scientific and technological pattern. However, the EU, unlike the United States, depicts a negative specialisation in the most dynamic, faster-growing and technology-intensive fields, such as medical equipment, telecommunications or audio-visual electronics. Moreover, in terms of key enabling technologies, the United States presents a consistent positive specialisation in ICT, biotechnology and nanotechnology, while the EU presents a mixed picture. It still presents a lower relative specialisation in ICT and biotechnology technologies, while it has offset the lower relative specialisation in nanotechnology that it suffered at the beginning of the decade.

At a national level, Denmark and Ireland depict a positive and increasing specialisation in health technologies or environmental technologies, Finland in ICT and the Netherlands in nanotechnologies.

At a regional level, ICT technologies are concentrated around Finland, South East England, Belgium, the Netherlands and some core areas in France and Germany. For biotechnology, regions with large university centres at the core of the EU depict a positive specialisation.

However, it is important to remember that smart specialisation is a dynamic strategic process where regions and member states need to identify their long-term competitive advantages based on their local strengths, and define those actions that can lead them to maintain and/or create their competitive position.

While further work will be needed to assist regions and countries in this self-discovery process and evaluate the results and impacts, the specialisation indexes can provide an initial framework to identify existing strengths and help identify potential drivers and barriers leading to particular specialisation patterns and dynamics.

2.1. Evidence base for smart specialisation

Smart specialisation has recently gained political and analytical importance in Europe as a potential solution to problems of research fragmentation and imitation of research patterns, which will build critical mass, to maximise research and innovation outputs in all regions in Europe. Moreover, in the current context of fiscal consolidation, 'specialisation strategies can be conducted in ways that also enhance innovative specialisations and competitive advantages in the post-crisis period, facilitate repositioning strategies and underpin answers to severe global risks, e.g. energy shortage, climate change[389].'

389 Giannitsis, A and Kager M (2009): 'Technology and specialisation: Dilemmas, options and risks?', *Expert group 'Knowledge for Growth', May 2009.*

Smart specialisation as a dynamic and entrepreneurial process to identify and build competitive advantages in science and technology

The concept of smart specialisation should be understood as a dynamic 'process of finding the right areas to focus on[390]'. As such, smart specialisation does not call for imposing specialisation through some form of top–down industrial policy. On the contrary, it requires an entrepreneurial process of discovery involving all stakeholders to identify and reveal what a country or region does best in terms of science and technology, and where they can expect to excel. This process of discovery needs to be attached to broader political goals and must identify governance mechanisms and criteria to guide choices.

Smart specialisation is an important policy rationale and concept for regional innovation policy. It promotes efficient, effective and synergetic use of public R&I investments and supports Member States and regions in diversifying and upgrading existing industries and in strengthening their innovation capacity. In a nutshell, smart specialisation is about placing greater emphasis on innovation and having an innovation-driven development strategy in place that focuses on each region's strength and competitive advantage. It is about specialising in a smart way, i.e. based on evidence and strategic intelligence about a region's assets and the capability to learn what specialisations can be developed in relation to those of other regions.

Many EU Member States and regions have a long-standing experience in developing and implementing innovation strategies. In many cases these strategies already include most or many of the elements that would justify them as being "smart", i.e. they were developed based on a sound assessment of a region's competitive assets and potential, including a SWOT analysis, a broad and intense stakeholder consultation, a deep understanding of business R&I needs, and they have developed a policy mix that covers the whole knowledge triangle. A few examples from regions that have embarked on such a smart specialisation exercise are included in this brochure. Yet many others have seen such exercises fail for want of strategic intelligence or political commitment or a lack of capacity or long-term political and budgetary commitment to implement such plans, properly evaluate them or sufficiently involve key stakeholders. For these there is a need to provide targeted assistance.

390 Foray D, David P A and Hall B (2009): 'Smart Specialisation: the concept', *Expert group 'Knowledge for Growth', May 2009.*

Smart specialisation requires the selection of fields to focus on resources. This process is not exempt of risks[391]

The very concept of specialisation requires the selection of specific areas to concentrate resources around specific goals and the non selection of others. If the market is unable to identify the key areas to specialise, the cost of inaction can be high. On the other hand, if an action needs to be taken, this selection may end up 'picking up losers', which may have high associated costs.

In the field of research and innovation, it is difficult to predict the results that will accrue from investments, and increasingly, technology developments and innovation can be based on the scientific results of many different and *a priori* unrelated disciplines. As such, targeting investment decisions towards narrow scientific areas may jeopardise the potential capacity to develop new technologies and innovations.

As a result, the analysis of the scope and scale of the need to specialise requires careful consideration. The choice and development of a smart specialisation strategy is a complex process where decision makers, e.g. governments, entrepreneurs, universities, need to have a clear vision for the future, build on their strengths, be aware of developments elsewhere, create networks and communities to maximise the use of available knowledge, and finally be able to take and manage risks.

In order to render the process as efficient as possible, more information is needed. European countries and regions need data that can help them assess their comparative and competitive strengths in different scientific and technological fields. Moreover, the research agents need new data to identify other countries and regions where research in similar fields is conducted so that they can network, build on each others' findings and create synergies between researchers.

391 A more in-depth review of the pros and cons of 'Smart specialisation' can be found in Pontikakis D, Kyriakou D and van Bavel R (eds) 2009: 'The Question of R&D specialisation: perspectives and policy implications', JRC Scientific and Technical Reports EUR 23834. For an analysis of the networking and regional innovation capacity, see also Varga, A. and Pontikakis, D., 2009. "Is networking a substitute or a complement to regional innovation capacity? Evidence from the EU's 5th Framework Programme". *JRC Scientific and Technical Reports, EUR 23836 EN.*

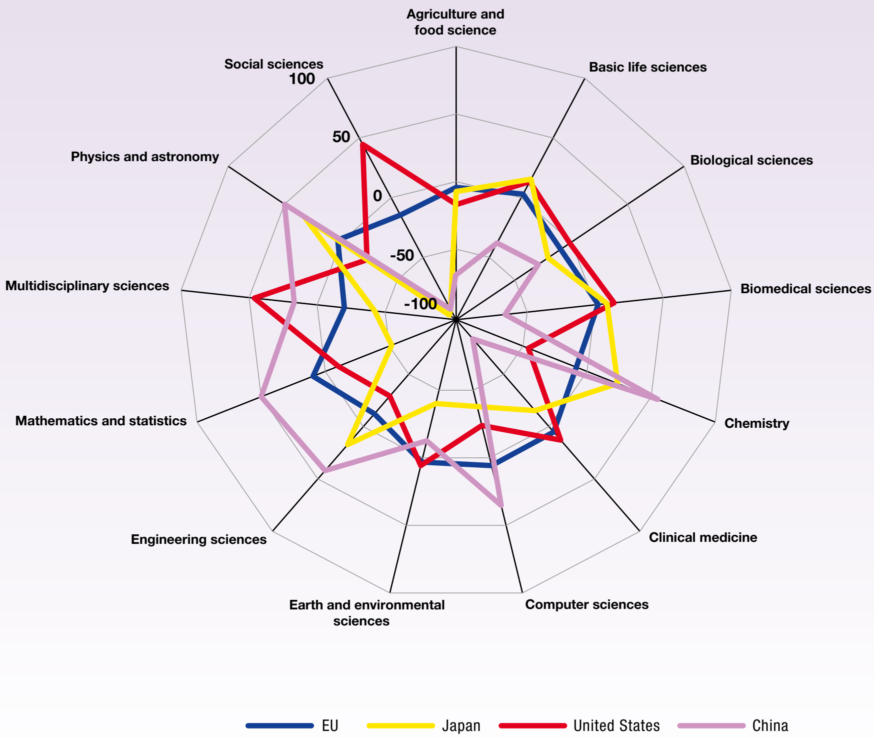
Much data is needed to inform the smart specialisation process. The specialisation indexes reveal the comparative advantage of one research and innovation system in one field and can help partially inform the process

A large battery of indicators can contribute to an understanding and explanation of the process of selecting and building scientific and technological competitive advantages in particular fields.

The scientific and technological specialisation indexes[392] rank high in this list. They indicate the areas where a country or region exhibits a stronger position than other countries or regions, and conversely the areas of relative weakness. In other words, they represent the different weight that scientific or technological fields carry in the overall research and innovation system in comparison with the rest of the world. As such, they do not reflect the absolute, but the comparative conditions for one area in one country, and their interpretation needs to be carefully done. The terminology 'positive' and 'negative' specialisation does not imply any normative value; they represent standard terminology in statistical analysis of specialisation indexes.

It should be noted that the specialisation indexes do not reflect the potential use of these technologies, but

FIGURE N.P.2.1 **Scientific specialisation in the EU, the United States, Japan and China, 2004-2006**



Source: DG Research and Innovation
Data: Web of Science (Thomson scientific) / CWTS, University of Leiden

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392 The mathematical definition of the specialisation indexes are calculated according to the following formula: RCAki = 100 x tanh ln {(Aki/ΣiAk)/(ΣkAki/ΣkiAki)}, with Aki 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.

the production; positive- and negative-specialisation indexes do not always correspond to the existence of favourable or unfavourable conditions for these scientific or technological fields in a given country, as they cannot measure other important variables, such as the existence of clusters of complementary activities or critical mass which are crucial to construct scientific, technological or economic competitive advantages.

2.2. Scientific and technological specialisation of the EU

The following sections present a series of scientific and technological specialisation profiles for the EU, the United States and Japan, and analyse in more detail the specialisation indexes for Member States and their regions, in a number of particularly interesting technological fields.

The EU's scientific system is highly diversified with little relative specialisation in any particular field

The EU has developed a diversified scientific base where most fields are represented at the average world level (Figure N.P.2.1). To some extent, this pattern responds to the vast importance of the EU scientific production that largely influences the world patterns of scientific production. Nevertheless, the United States, which also has very large scientific production, presents a less diversified system, as it depicts a stronger specialisation in social sciences, multidisciplinary science and to a lesser extent, clinical medicine. Japan and China present less diversified scientific systems, with Japan showing a positive specialisation in physics, engineering and chemistry, and China on maths, engineering and computer science.

The EU-27, like most other large economies, counts on a highly diversified technological system, with a comparatively slight negative specialisation in high-technology sectors, such as telecommunication, electronics or medical equipment

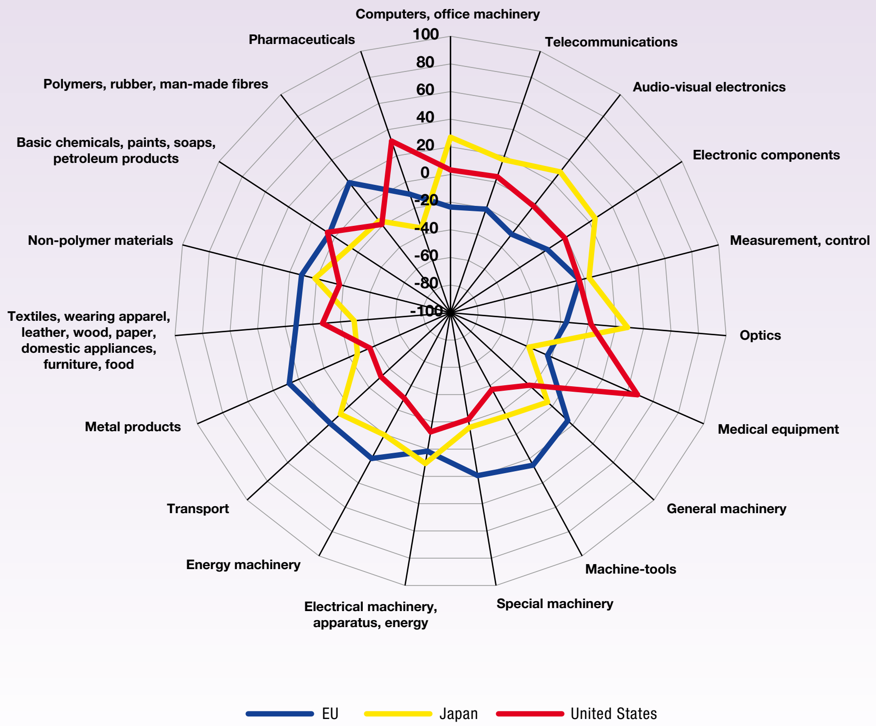
EU-27, like the United States and Japan, has maintained a relatively stable technological specialisation pattern in recent years. On average, large economies have diversified technological systems where few specific fields stand out. However, it is important to point out that in comparison, Japan has a relative specialisation in highly research-intensive electronic fields such as computers, office and machinery, telecommunications, audio-visual electronics, electronic components or optics. The United States specialises more on high-tech and high added-value technological fields related to medical equipment and pharmaceuticals, while the European Union seems to have a stronger specialisation in lower research-intensity sectors such as metal production or machinery-related technologies and a negative specialisation in ICT-related sectors such a telecommunications, audio-visual electronics or electronic components.

As for science, European technology tends to be highly diversified with a relative specialisation in machine-related and metal-product technologies

The European Union's technological pattern presents a fairly diversified picture with a certain specialisation in medium technology-intensive areas such as metal-product-, transport- or machinery-related technologies (Figure N.P.2.2). This pattern contrasts with that of the United States or Japan, which present a less uniform distribution of technological development. More precisely, the United States counts on strong specialisation on high technology fields such as medical equipment or pharmaceuticals, while Japan presents a higher specialisation in other high technological fields such as telecommunications, and electronics-related technologies.

These patterns have been stable over time and somehow reflect the differences in the economic structure of Europe vis-à-vis its main trading competitors. Although it is difficult to identify whether the scientific and technological patterns are the cause or the consequence of a given productive specialisation, this data shows that Europe has a lower relative specialisation in the production of high-technology knowledge. The continuation of this pattern can cast some doubts on the competitiveness of its industry to produce and export high technology and added-value products.

FIGURE N.P.2.2 **Technological specialisation in the EU, the United States and Japan, 2005-2006**



Source: DG Research and Innovation
Data: JRC-IPTS , EPO, WIPO
Note: Patent applications by region of residence of the inventor(s).

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While it is difficult to establish close relationships between scientific and technological specialisation profiles, some patterns can be identified

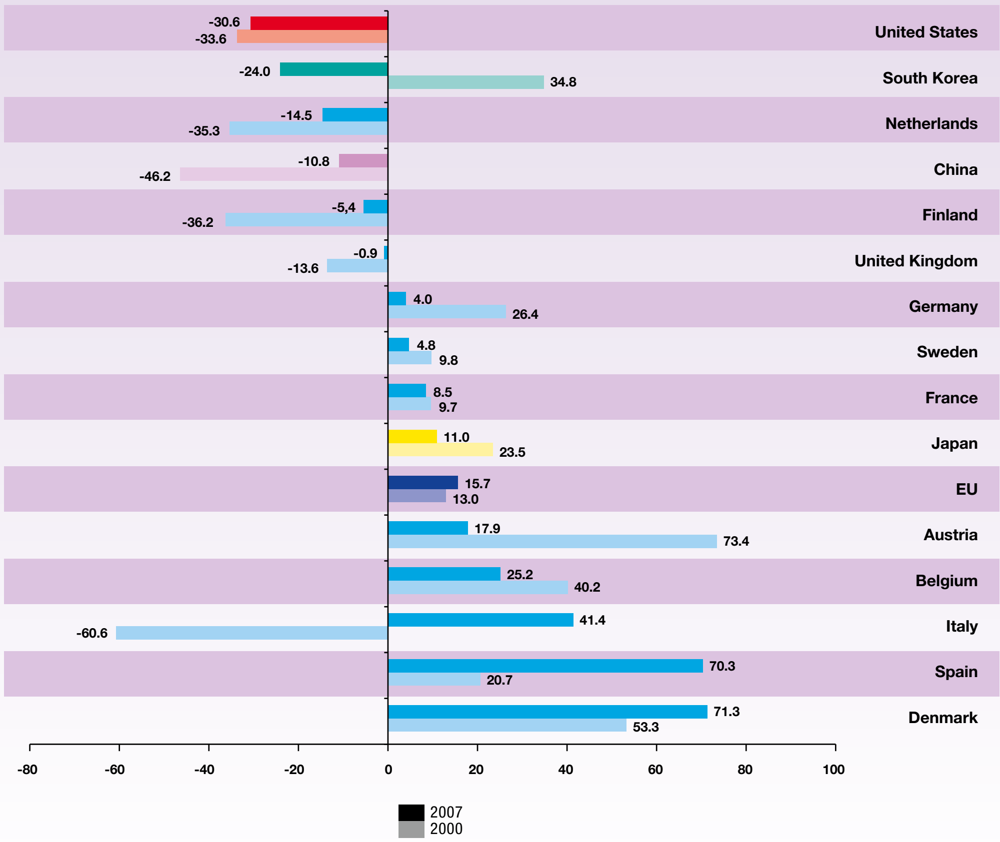
The United States depicts a positive scientific specialisation in life science and biomedical sciences and a technological specialisation in pharmaceuticals and medical equipment. Japan shows a positive specialisation in physics and engineering and a positive specialisation in ICT-related technologies.

2.3. Specialisation in environmental and health technologies

The European Union is increasingly improving its relative strengths in developing new technologies aimed at improving the environment, including climate change

In terms of relative specialisation in environmental technological fields, the EU depicts a positive specialisation pattern, in contrast to the United States, with a negative specialisation index (Figure N.P.2.3). Member States such as Spain, Denmark, Hungary and the Czech Republic lead the list of countries where environmental technologies play a comparatively stronger role in the national technological production. It is important to highlight the case of Italy,

FIGURE N.P.2.3 **Environmental technologies - specialisation index by country, 2000 and 2007**



Source: DG Research and Innovation
Data: PCT JRC-IPTS, OECD
Note: Patent applications by region of residence of the inventor(s).

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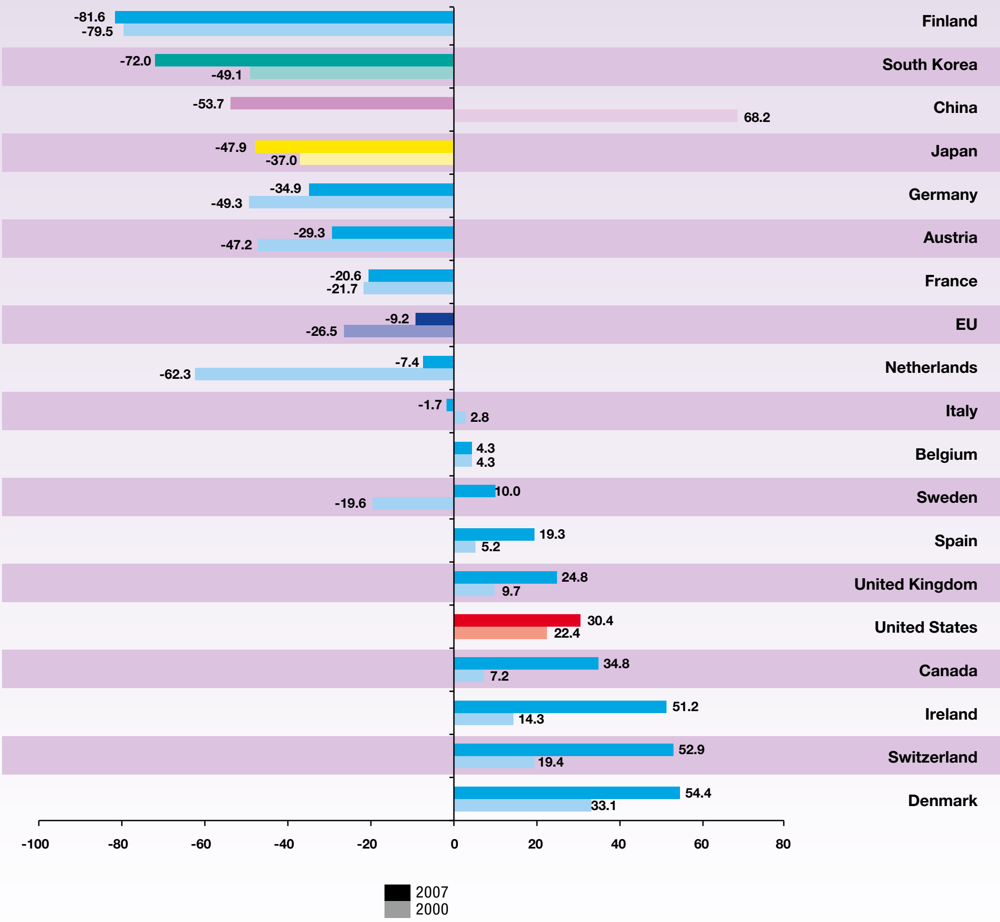
which in the last decade reversed an important negative specialisation index and now has moved to become one of the most promising technological fields.

The EU suffers a negative specialisation in health technologies, where the United States has an absolute and relative advantage

The United States, overall, has both an absolute and comparative advantage in the development of health-related technologies. While the EU-27 has been catching up in the last decade, it still suffers from a negative specialisation in this field, as other technological fields are comparatively better positioned (Figure N.P.2.4). However, within Europe, there are some countries that have developed very strong positions in health-related technologies such as Denmark, Ireland or the United Kingdom. This specialisation has been more marked over time, which suggests a process of increasing specialisation in these technologies in these countries, which most likely count on the right factors (both in terms of resources like institutions and policies) allowing to them to concentrate their research and scientific efforts towards these fields.

It should be noted that both highly research-intensive systems such as South Korea and Japan also count on a high negative specialisation in these technologies, which suggest a high specialisation in other technological fields, and likely, a lack of the right conditions to develop these types of technologies.

FIGURE N.P.2.4 **Health technologies - specialisation index by country, 2000 and 2007**



Source: DG Research and Innovation
Data: JRC-IPTS, OECD
Note: Patent applications by region of residence of the inventor(s).

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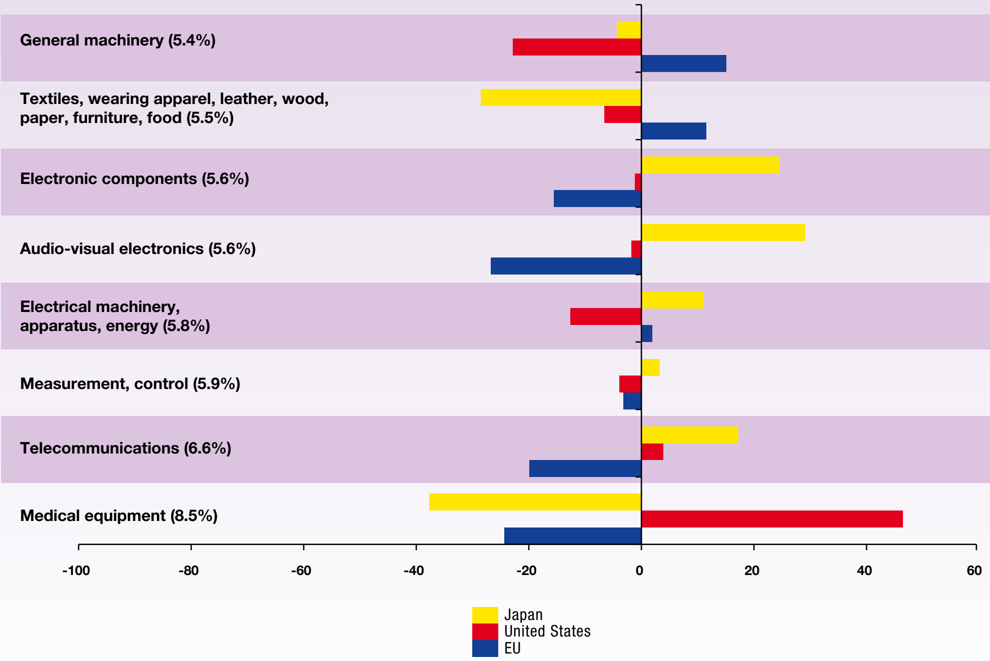
2.4. Specialisation in new growth areas and general-purpose technologies

Technological fields evolve according to their own idiosyncratic characteristics, which may include historical factors, knowledge developments or changes in economic and societal demands. As a result, comparisons across fields are difficult. However, some technological fields seem to be more dynamic over time, presenting higher growth rates in patenting activity. As figure N.P.2.5. shows, fields such as medical equipment, telecommunications or measurement and control technologies have been growing faster than other fields in the recent past.

FIGURE N.P.2.5 **Fast growing technology fields[1] - specialisation index, 2004-2006**



Source: DG Research and Innovation

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Data: JRC-IPTS, OECD

Notes: (1) Fast growing technology fields over the periods 2003-2004 and 2004-2005. Growth of patent applications between the two periods is given in brackets.
(2) Patent applications by region of residence of the inventor(s).

The European Union presents a negative specialisation in the most dynamic, faster-growing and technology-intensive fields

The EU seems to lag behind in these technology-intensive sectors, as the specialisation indexes are negative for these technologies, indicating that there are fewer EU patents in these areas than there would be if patent numbers corresponded to the EU's overall technological activity.

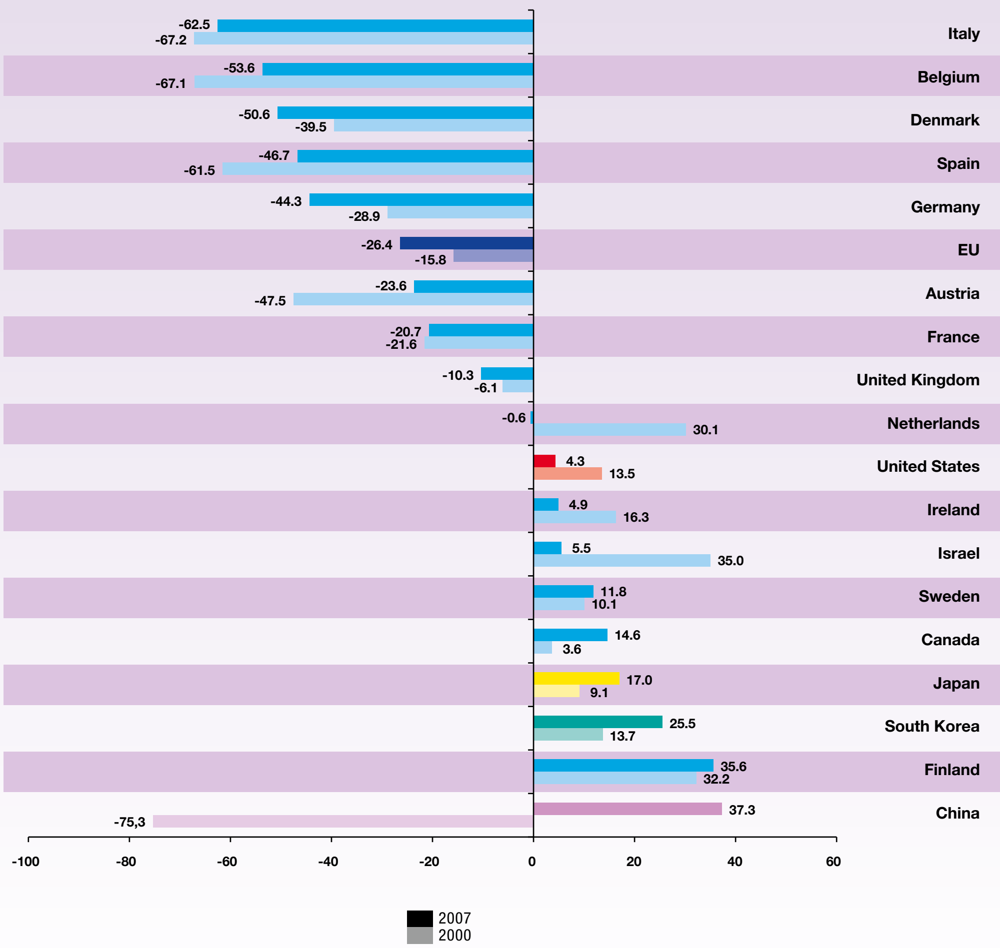
Moreover, general-purpose technologies, such as ICT, biotechnology or nanotechnology, have been at the basis of recent important technological developments and they are expected to be crucial for future economic growth.

The EU has a negative specialisation in ICT, although some Member States and especially, some regions within them, show a positive technological specialisation in these fields

The EU still shows a lower specialisation in the development of ICT technologies. Evidence at the level of firms in the IT sector suggests that the EU's R&D deficit may be due to constraints on the rapid growth of new-technology entrants in the EU compared to that of the United States[393]. With the exception of Finland, Sweden and to a lesser extent Ireland, the role of ICT in the EU has been shrinking over time. In contrast, in addition to the United States, countries in Asia, e.g. China, South Korea or Japan, have become increasingly specialised in this field internationally,

393 Source: DG Enterprise: 'European Innovation Scoreboard, 2010' (p.49).

FIGURE N.P.2.6 ICT technologies - specialisation index by country, 2000 and 2007



Source: DG Research and Innovation
Data: JRC-IPTS, OECD, Eurostat
Note: Patent applications by region of residence of the inventor(s).

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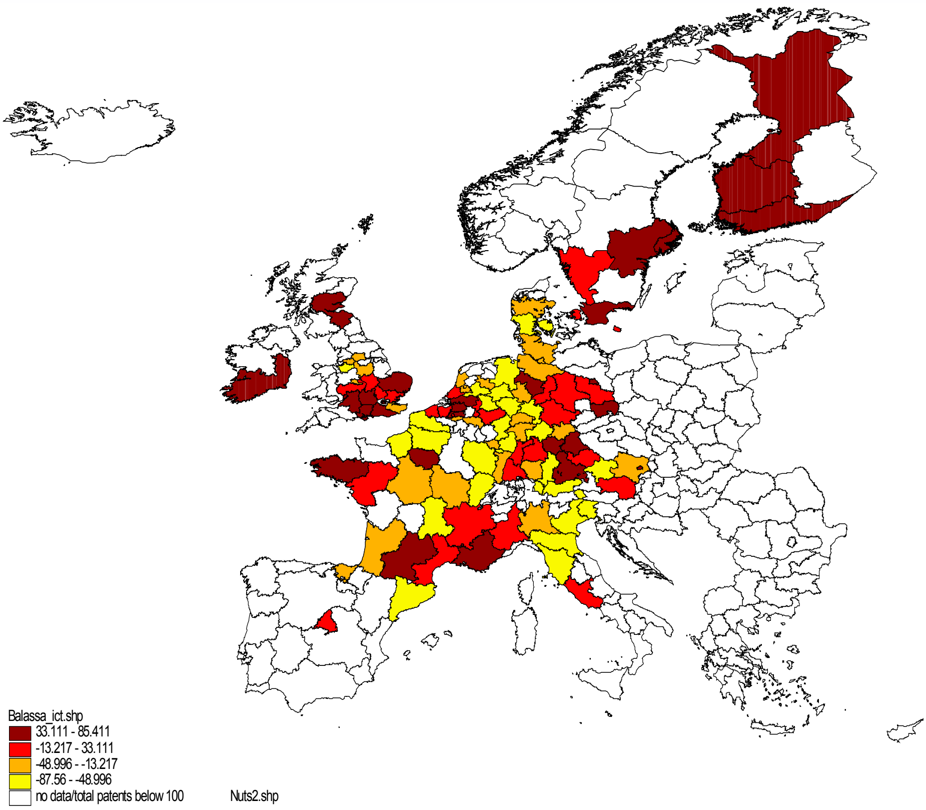
which makes them an important global hub for ICT-related technological development (Figure N.P.2.6).

It is important to note that in dynamic terms, most countries have maintained their specialisation patterns over time – China being a notable exception – passing from a large negative specialisation in 2000 to a significant positive specialisation in 2007.

In recent years, many regional governments have expressed their interest in entering the biotechnology and ICT fields. The potential high returns of these technologies, either on their own or in interaction with

FIGURE N.P.2.7 **EU technological specialisation in ICT technologies at NUTS 2 regional level: 2004–2006(1)(2)**



Source: DG Research and Innovation, JRC-IPTS
Data: OECD, Eurostat
Notes: (1) Patent applications by region of residence of the inventor(s).
(2) The regional analysis only takes into account regions that produce more than 100 patents in order to avoid misleading interpretation of specialisation patterns in very low technology production intensive regions. The regions are distributed in four groups, each of which contains 25% of the analysed regions.

other fields, have attracted increasing interest and investment from local and regional governments.

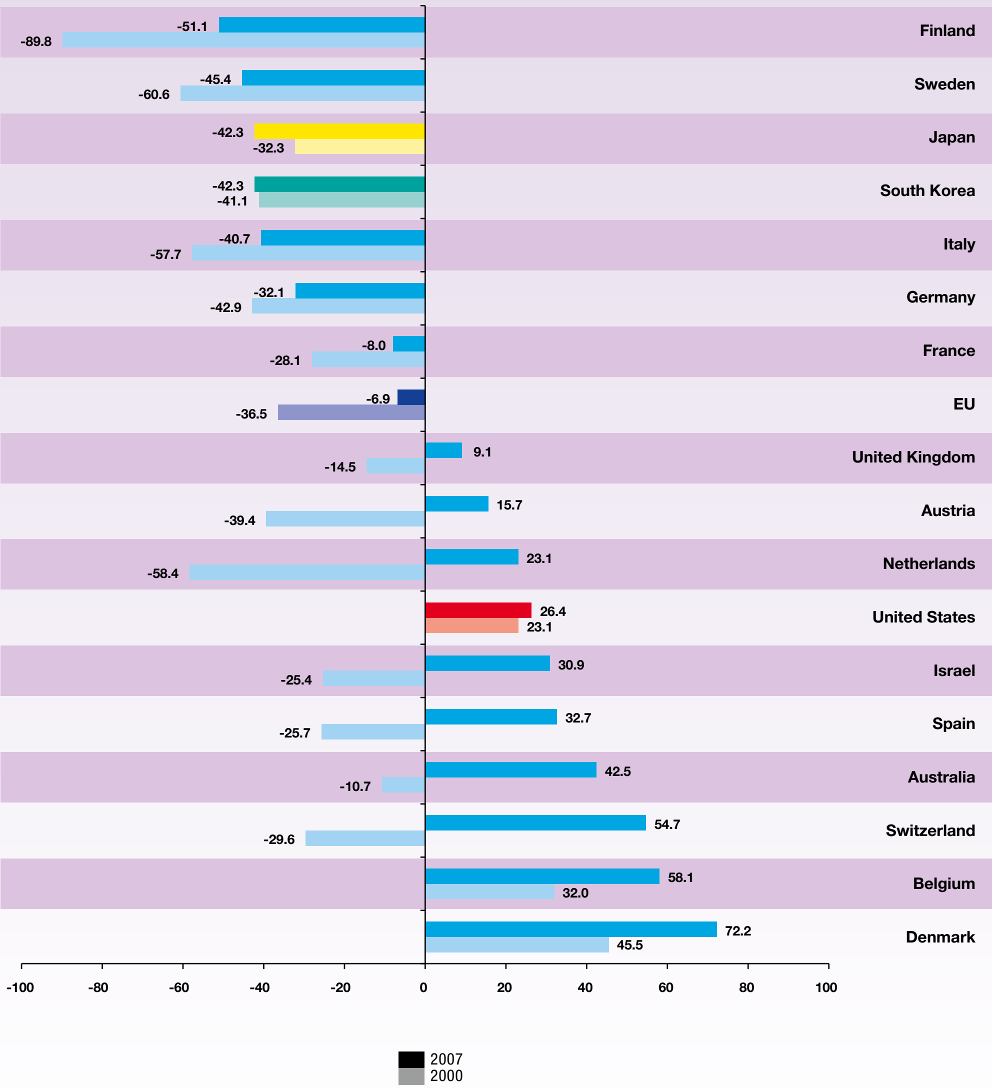
At the regional level[394], ICT technologies are highly concentrated around Finland, the South East of England and some core regions in Belgium, the Netherlands, some core regions in Germany and France, and finally in some capital regions of Île-de-France and Madrid (Figure N.P.2.7).

394 As it happened for Member States, the statistical construction of the indicator requires the analysis to be focused on those regions counting a statistical significant number of patents. Only regions with 100 or more patents in any of the analysed years are taken into account in the study. 108 regions comply with this requirement.

The emerging biotechnology and nanotechnology fields seem to be concentrated around core countries of the EU, such as the United Kingdom, Belgium and the Netherlands

In terms of biotechnology, the field seems to be less mature and stable than that of ICT, and many countries have experienced significant changes in their specialisation patterns over the last decade. The United States shows a positive specialisation in this field, while the EU has relatively advanced in the last decade, although still depicts a slight relative negative specialisation (Figure N.P.2.8).

FIGURE N.P.2.8 **Biotechnology - specialisation index by country, 2000 and 2007**



Source: DG Research and Innovation
Data: JRC-IPTS, Fraunhofer ISI, Eurostat
Note: Patent applications by region of residence of the inventor(s).

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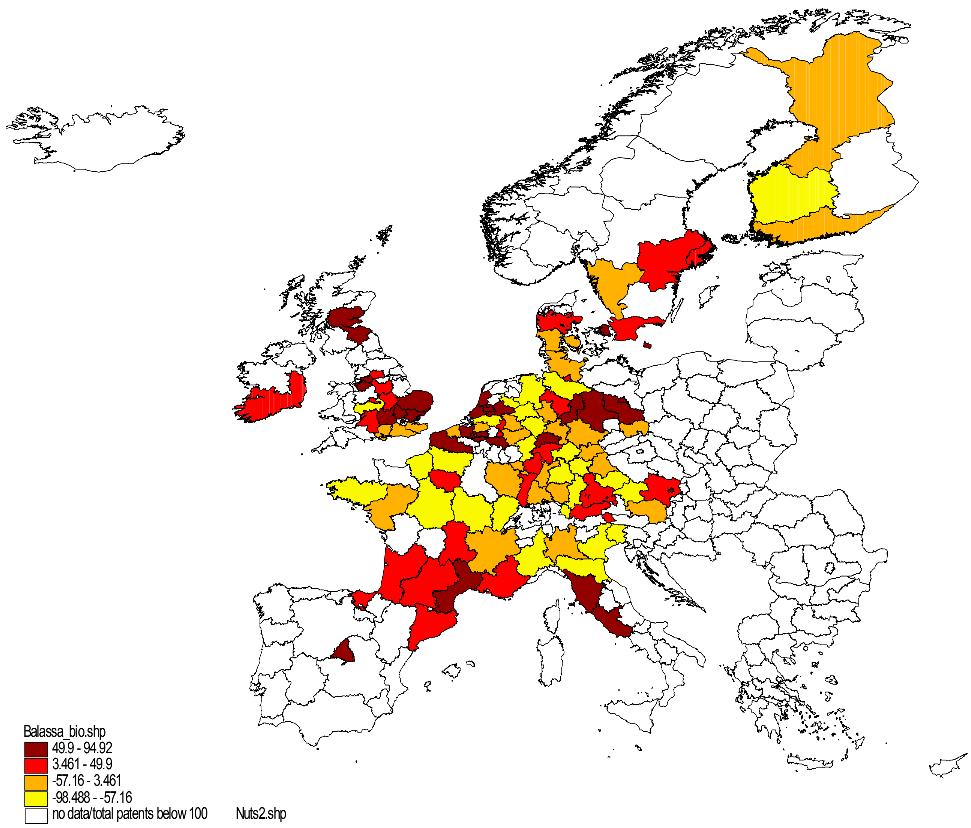
Countries like the United Kingdom or the Netherlands have reverted negative specialisation patterns from 2000 into a positive relative specialisation, which suggest a relative improvement of the conditions in these countries for biotechnology. Belgium and Denmark have increased their specialisation

FIGURE N.P.2.9 **EU technological specialisation in biotechnology at NUTS 2 regional level: 2004–2006(1)(2)**



Source: DG Research and Innovation, JRC-IPTS
Data: Fraunhofer ISI, Eurostat
Notes: (1) Patent applications by region of residence of the inventor(s).
(2) The regional analysis only takes into account regions that produce more than 100 patents in order to avoid misleading interpretation of specialisation patterns in very low technology production intensive regions. The regions are distributed in four groups, each of which contains 25% of the analysed regions.

pattern. This data confirms the high importance of biotechnology for health technologies, as the countries with higher specialisation patterns in medical technologies also present a high specialisation pattern in biotechnologies.

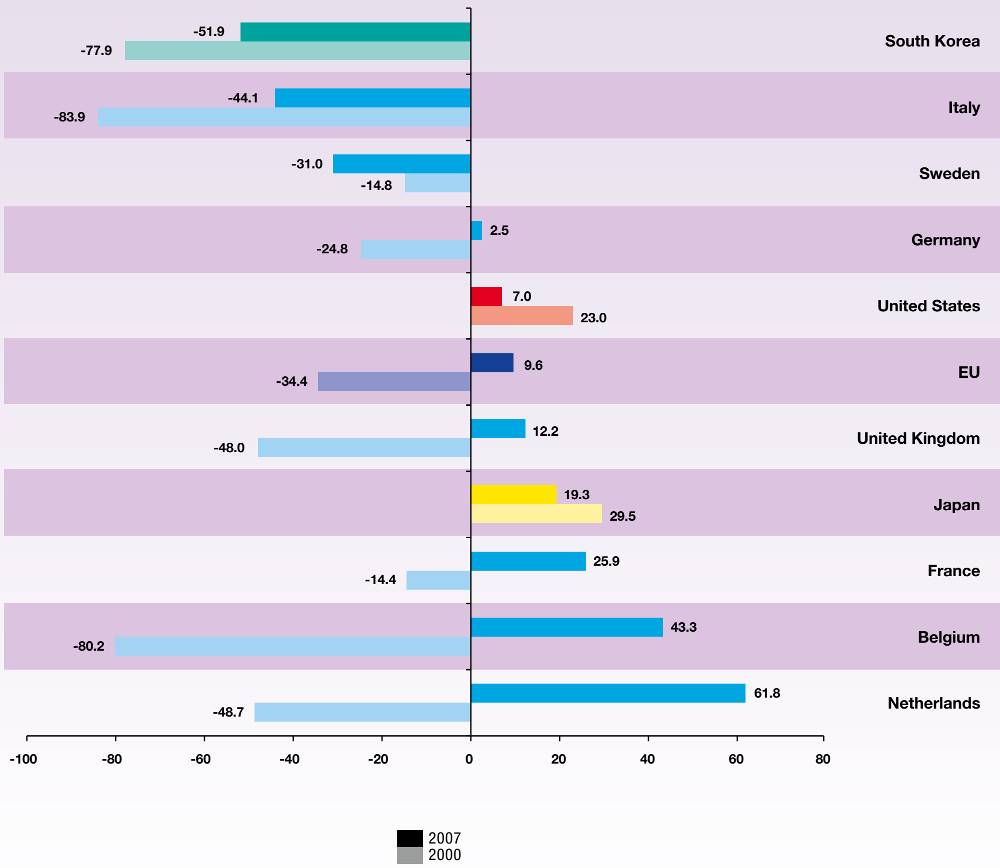
Biotechnology is highly concentrated in a few regions in Europe

Regions with large university centres in the south East of England, Scotland, the south of France, Belgium, the Netherlands, Denmark, Germany, Madrid in Spain and Lazio in Italy are more highly specialised in science-dependent biotechnology (Figure N.P.2.9).

In nanotechnologies, the EU is catching up with Japan and the Unites States. Within the EU, the Netherlands, Belgium and France are developing an important specialisation

The field of nanotechnology, like biotechnology, is more novel than that of ICT, and in the last decade, many countries have managed to develop an important specialisation in this field. While still emerging and not consolidated, the dynamic analysis of the specialisation indexes reveals that some countries seem to be becoming better positioned, suggesting the existence of significant comparative advantages for the development of these fields, e.g. Belgium and the Netherlands (Figure N.P.2.10).

FIGURE N.P.2.10 **Nanotechnology - specialisation index by country, 2000 and 2007**



Source: DG Research and Innovation
Data: JRC-IPTS, OECD
Note: Patent applications by region of residence of the inventor(s).

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Overall, the EU shows a small positive specialisation in these fields comparable to that of the United States. This value masks high internal differences, as a few countries in Europe, the Netherlands, Belgium, the United Kingdom, France and Germany, seem to concentrate the large majority of patents. This geographical concentration of the nanotechnology patents at the European core seems to suggest that the field requires large investments and benefits from large concentration and spillover effects.