

# The European Union

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## INTRODUCTION

The year 2004 saw the European Union (EU) swell from 15 to 25 Member States with the entry of ten countries from Eastern and Southern Europe (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia). Accession on such a large scale was a first in Europe and cannot be compared with the successive waves of accession to the European Community, such as that of Greece in 1981, Portugal and Spain in 1986, or Austria, Finland and Sweden in 1995. Nearly 75 million people joined the EU in 2004, swelling its population by 20% (Table 1). The 115,000 additional researchers will need to integrate the European Research Area; this area remains a shared goal of all Member States, even if it is not yet a reality.

In 2000, the meeting of the European Council in Lisbon undertook to create a European Research Area by creating a joint dynamic for research and development (R&D) and increasing expenditure to make the EU 'the most competitive and dynamic knowledge-based economy in the world'. In Barcelona in 2002, the European Council reasserted this objective and proposed that the level of expenditure on research and development (GERD) be raised to 3% of GDP by 2010. To date, we are still far from this target: the GERD/GDP ratio was only 1.9% on average for the EU in 2001 and the entry of the new Member States lowers this proportion to 1.8% (Table 1). Only two

**Table 1**  
POPULATION, GERD AND GDP in the EU, 2001  
USA and Japan are given for comparative purposes

Country/zone	Population (millions)	GDP (G\$)	GERD (G\$)	GERD/GDP (%)
EU15	381	9 680	185	1.91
EU25	455	10 383	189	1.82
USA	286	10 020	275	2.74
Japan	127	3 390	104	3.06

Sources: OECD (Main S&T Indicators) and EUROSTAT data, OST estimations and computing.

**Table 2**  
GERD/GDP RATIO IN THE EU, 2001, AND CHANGE, 1996–2001

Country/zone	GERD/GDP 2001 (%)	Change 2001/1996 (%)
Germany	2.51	+11
France	2.23	-3
United Kingdom	1.89	+1
Italy	1.07	+6
Spain	0.96	+16
Netherlands	1.89	-6
Greece	0.64	+31
Belgium	2.17	+21
Portugal	0.84	+47
Sweden	4.27	+23
Austria	1.92	+20
Denmark	2.39	+29
Finland	3.42	+35
Ireland	1.17	-11
Luxembourg <sup>1</sup>	1.71	-
<b>EU15</b>	<b>1.91</b>	<b>+7</b>
Poland	0.67	-6
Czech Republic	1.30	+25
Hungary	0.95	+46
Slovakia	0.65	-31
Lithuania	0.68	+31
Latvia	0.44	-4
Slovenia	1.57	+9
Estonia	0.66	+1
<b>EU25<sup>2</sup></b>	<b>1.81</b>	<b>+7</b>

### Notes

<sup>1</sup> Data from 2000.

<sup>2</sup> Excludes Cyprus and Malta.

Sources: OECD (Main S&T Indicators) and EUROSTAT data, OST estimations and computing.

countries of the 15-member European Union (EU15) have exceeded the 3% target and most of the others do not even come close; not a single new member measures up to the European average (Table 2).

Under the circumstances, what objectives can the 25-member EU realistically set itself? Should it raise the performance of the most advanced countries to a level comparable to that of the USA and Japan or concentrate efforts on boosting those countries far below the European average? In this chapter devoted to the EU, science and

technology (S&T) indicators will show the strengths and weaknesses of a widespread region that occupies a prominent place on the international R&D scene. The assets and shortcomings of the now enlarged EU will also be set out.

**A GREAT SCIENTIFIC POWER**

In 1993, the scientific production of the 15-member EU, calculated in terms of share of the world’s scientific publications recorded in the SCI database, was lower than that of the USA (Figure 1). In 1995, the EU overtook the USA and in 2001 its production was five points higher than that of the USA. In other words, the EU15 – which now accounts for one-third of the world’s scientific production – asserted itself in the last decade of the twentieth century as the world’s leading scientific power. Enlargement to 25 increased the share of scientific publications, which accounted for nearly 36% of the world total in 2001 (Figure 2).

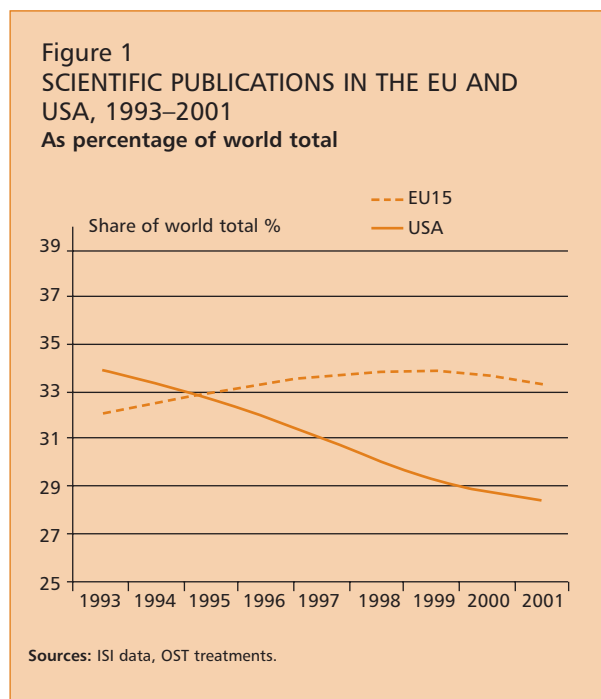
This performance is the result of two trends: a decline in the USA’s share of world scientific production in the 1990s coupled with an increase in the EU’s share, particularly in

the early 1990s. If we compare scientific production and GERD, the European performance is remarkable. The USA’s domestic expenditure on R&D is very much greater than that in the EU. The same holds for public expenditure (by universities, research bodies, etc.) which is the main producer of fundamental knowledge (Table 3). It can therefore be said that academic research is thriving in the EU, even if, in fact, it varies greatly from one country to another, as we shall see.

The EU’s scientific production as a share of the world total exceeds that of the USA in all disciplines. For instance, the share of the EU15 is close to 38% in world medical research, where it may be regarded as highly specialized (Table 7). On the other hand, it is less specialized in the engineering sciences (less than 30% of world production) but nonetheless ahead of the USA. The entry of ten new Member States significantly increases the EU’s scientific production in physics, mathematics and chemistry, prominent disciplines in the Eastern European countries.

This rather rosy picture should be qualified, however. Although the EU has indeed gained in terms of scientific production, that is in the number and share of scientific publications, it has progressed a great deal less in terms of visibility, as measured by the number of citations. In 2001, the publications of the EU15 received one-third of citations worldwide (Figure 2), a much lower figure than that of the USA, which accounted for 42% of the total. Even though the USA’s share has been decreasing since 1993 while that of the EU has remained stable, the fact that the gap between the EU and the USA persists reflects differences in the impact of science in the two great world powers.

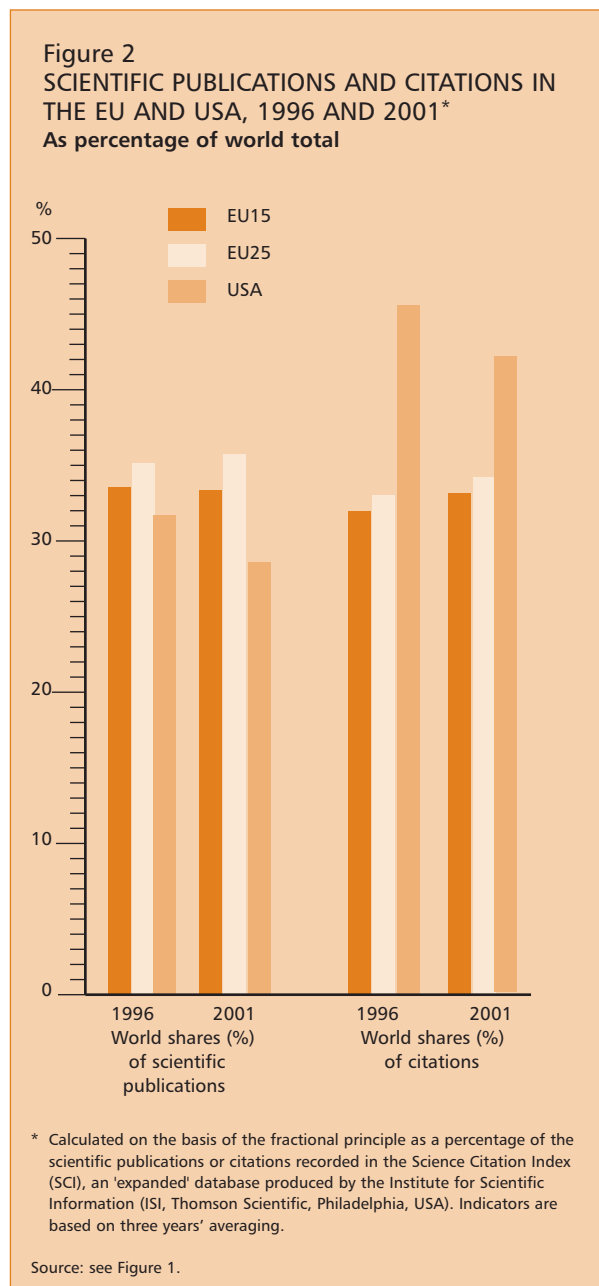
This gap is also due to differences between the two regions in terms of the branches of science concerned. The EU’s impact index, as measured by the ratio of the number of citations to that of publications, is higher than the world average value of 1 in all but two disciplines: medical research and basic biology. These are the very disciplines with a high impact index in the USA. Is this a reflection of the difference in investment in the life sciences and medical research between Europe and the USA? Europe



will have to make sure it remains very competitive in these fields, both considered essential for innovation.

### EUROPE LOSING GROUND IN TECHNOLOGY

Although European scientific research can compete with that of the USA, the situation is quite different when it comes to



technological research. Two indicators show the relative weaknesses of the EU: the volume of R&D expenditure by businesses (BERD) and the share of patent applications filed.

BERD in the USA is 70% higher than corporate expenditure in the EU15. The difference amounted to \$PPP80 billion<sup>1</sup> in 2001 when the EU was still restricted to 15 members. BERD represented 2% of GDP in the USA as against 1.24% of GDP in the EU. By looking at the source of funding for R&D in businesses (Table 4), we see two reasons for this disparity. First is the level of public aid provided directly to businesses. In 2001, public contracts for businesses represented approximately US\$20 billion in the USA, double that in the EU15. Second, there is a substantial difference in firms' own investment in R&D between the USA and Europe: US\$70 billion in 2001 and growing because BERD is progressing rapidly in the USA but only very slowly in the EU.

Such wide disparities are not found in all industrial sectors. Expenditure on R&D by European (EU15) businesses is comparable to that of their American counterparts in some sectors. These include transportation, which amounted to approximately \$PPP19 in 2000, and pharmaceuticals, which represented \$PPP13 (Table 5). By contrast, the electronic sector, which ranks top in the EU with 20% of R&D expenditure by the private sector (i.e. \$PPP21), accounts for one-third of R&D expenditure by businesses in the USA (i.e. \$PPP55). In the buoyant sector of engineering and computing services, the USA spends 80% more than the EU.

These differences in terms of investment are reflected in the respective abilities of the EU and the USA to innovate, as measured by filed patent applications. In 2001, the EU15 filed 42% of European patent applications (Figure 3), compared with nearly 50% in 1986. European production fell sharply in the late 1980s and early 1990s (Figure 4). It seems to have evened out since 1998. Meanwhile, there was a significant rise in the USA: whereas the share of European patent applications filed by the USA amounted to 28% in 1986, this had climbed to 33% only ten years

1. The unit of account is per billion dollars by converting national currency to US\$ using 'purchasing power parities' (PPPs).

**Table 3**  
GERD IN THE EU AND THE USA, 1996 AND 2001\*  
By sector

Country/zone	GERD (G\$)		GERD performed by the public sector (\$PPP)		GERD performed by the private sector (\$PPP)	
	1996	2001	1996	2001	1996	2001
EU15	134	185	50	65	84	120
EU25	136	189	–	–	–	–
USA	198	275	53	74	145	201

\* The government, higher education and non-profit institutions sectors recorded separately under the OECD classification have been grouped here in the public sector category.

Sources: OECD (Main S&T Indicators) and EUROSTAT data, OST estimations and computing.

later. This rise also reflects the mounting interest of American businesses in the European market. Conversely, the share of US patents granted to European inventors declined from 24% in 1986 to 17.5% in 1998 and seems to have levelled off since then.

Here again, this global assessment fails to account for sectoral disparities. In the European patent system, the EU leads in the machine transport sector (57% of the world total in 2001) and in the sectors of household consumption, construction building and public works (55% of the total). The EU has a different profile in the US patent system with regard to specialization, reflecting the interest of a number of industrial sectors in the US market. Europe specializes in chemistry and materials, industrial processes, machine transport, pharmaceuticals and biotechnologies.

In 2001, in each of these four technological branches, it filed more than 20% of the patents granted by the US Patent and Trademarks Office (USPTO).

It can be concluded from this analysis of R&D expenditure and S&T production that the EU is holding its own in terms of scientific performance but lagging behind when it comes to technology, in a context of inadequate expenditure on research, especially by the business sector. This assessment led the Barcelona European Council to emphasize the need to increase industrial investment in R&D.

#### DISPARITIES WITHIN THE EU REINFORCED BY ENLARGEMENT

Although the EU can be considered a single region comparable to the USA, there are significant differences within Europe as regards R&D. These differences will only be accentuated by the addition of ten new Member States. The disparities first appear in terms of the GERD/GDP ratio, which can vary as much as threefold from one country to another. Even when the EU counted only 15 members, expenditure on R&D ranged from a high of more than 4% in Sweden to less than 0.7% in Greece. In other words, depending on the country, the percentage of GDP can be more than double the European average (1.91% for the EU15 in 2001) or less than half of it. Both Slovenia and the Czech Republic, the new Member States with the greatest R&D intensity, fall below the European average. The largest of the new Member States, Poland, spends less than 0.7% of

**Table 4**  
BERD IN THE EU AND USA, 2001\*  
By volume and source of funds

Country/zone	BERD (G\$)		
	Funding by industry	National public contracts	Total execution
EU15	110.6	9.8	120.3
USA	181.3	19.2	200.5

\* The data here incorporate both foreign and business funding.

Sources: OECD (Main S&T Indicators) data, OST estimations and computing.

GDP on R&D. Even the GERD of Poland, the Czech Republic and Hungary combined was only equivalent to GERD by Belgium in 2001.

If we classify EU countries by their position with regard to the GERD/GDP ratio and the way in which that ratio evolved between 1996 and 2001, we can distinguish five groups of countries (apart from Cyprus, Luxembourg and Malta) (Table 2 and Figure 3).

The first group is represented by only two countries, Finland and Sweden. The ratio of GERD to GDP is higher than in the USA or Japan and growing. These countries maintain a high level of R&D.

The second group is made up of seven of the EU15 countries. GERD as a percentage of GDP is higher than the European average but lower than the ratio in the USA. Two sub-groups can be identified in terms of the way in which this ratio has changed:

- countries in which R&D expenditure has increased, namely Austria, Belgium, Denmark and to a lesser degree Germany;
- countries where there was no increase between 1996 and 2001, namely France, the Netherlands and the UK.

The third group is made up of seven countries which fall below the European average but where the percentage is higher than 0.9%. Three new Member States figure among these countries. Here again, two sub-groups can be distinguished:

- four countries in which GERD has increased in relation to GDP: the Czech Republic, Hungary, Portugal and to a lesser degree Spain;
- three in which it is stable or declining: Slovenia, which has the highest proportion of GERD in relation to GDP among the new Member States, Ireland and Italy.

The last group comprises six countries, including only one from the EU15, Greece. In two of these countries – Greece and Lithuania – GERD as a percentage of GDP is rising sharply. In the others, Latvia, Poland and especially Slovakia, it is declining.

The situation is clearly complex. Attention will certainly have to focus both on countries in the last group, which are a very long way from the target of 3% of GDP, and on those countries below the threshold of 1.9% which are showing signs of limiting investment in R&D. In sum, seven of the 23 Member States (excluding Malta and Cyprus where GERD/GDP ratio is negligible) will need to make a big effort to catch up; of these, six are new Member States.

The situation of the new Member States is often compared to that of the countries that joined the EU during the earlier waves of enlargement. The situation of the latter countries varies considerably, however. The GERD/GDP ratio for Ireland, which joined in 1973, has overtaken that of Italy, whereas the ratios for Spain and Portugal have increased and are still progressing. On the other hand, the ratio for Greece, which has been in the EU for 20 years, remains low despite steep growth.

The disparities observed in terms of financial resources are again visible when it comes to scientific production as

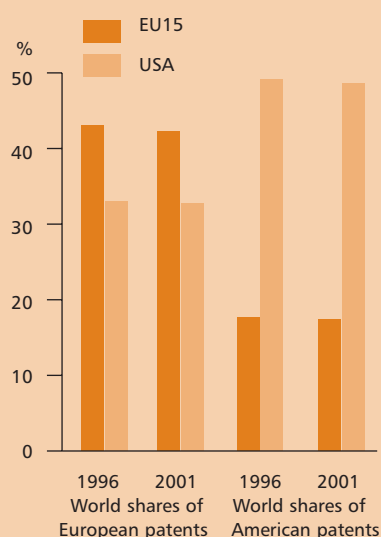
**Table 5**  
**BERD IN THE EU AND USA, 2001**  
**By economic sector**

Economic sector	BERD (\$PPP)	
	EU15	USA
Total manufacturing	89.6	129.6
Aeronautics	7.6	10.3
Electronics	21.3	55.3
Pharmaceuticals	13.0	12.9
Machinery and equipment	11.2	10.6
Transports	18.5	19.9
Chemicals	10.9	11.2
Natural resource-intensive industry	4.5	6.4
Labour-intensive industry	2.6	3.0
Total services	14.3	17.6
Electricity, gas and water supply	1.0	0.2
Construction	0.6	0.2
Transport/telecommunication services	3.0	2.4
Engineering/computing services	9.7	14.8
Grand total	103.8	147.2

The differences observed between this and the previous tables are due to the use of two different OECD databases (ANBERD and PIST), which are not updated at the same time. Data are not available for Austria, Greece, Luxembourg or Portugal and are therefore not counted in the figures for the EU.

Sources: OECD (ANBERD) data, OST estimations and computing.

Figure 3  
PATENT APPLICATIONS FILED BY EU AND USA  
IN EU<sup>1</sup> AND USA, 1996 AND 2001<sup>2</sup>  
As percentage of total



1 European patents include applications submitted to the European Patent Office and those submitted through the TCP channel which designate the European countries.

2 Indicators are calculated on the basis of the fractional principle and are based on three years averaging.

Sources: INPI, EPO and USPTO data, OST and CHI-Research computing.

measured by the world share of scientific publications. Three EU countries – France, Germany and the UK – accounted for more than a 5% share each of the world's scientific publications in 2001 (Table 6). These three countries account for 55% of the publications of the EU25; add Italy, the Netherlands and Spain, and the figure exceeds 75%. In other words, the remaining 19 countries share between them one-quarter of European scientific production.

In terms of trends, mention must be made of the increase in scientific production by the countries that joined the EU in 1986. For example, Portugal's world share, albeit small at 0.3% in 2001, nevertheless increased by nearly 70% between 1996 and 2001. As for Spain, its share rose from 2.1% in 1996 to 2.5% in 2001, widening

the gap with the Netherlands which ranks next. Scientific production by the three heavyweights of European research – France, Germany, the UK – on the other hand, has remained stable, or even slipped slightly.

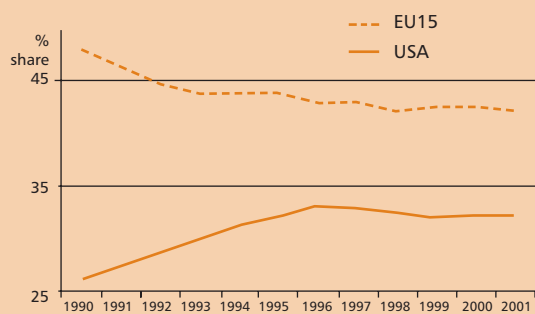
Still looking at scientific production, the ten new Member States carry little weight in this domain. Together, they contribute less than 3% of the world total, with Poland, the Czech Republic and Hungary being the main contributors. However, the trends between 1996 and 2001 were generally positive, especially for the three countries just mentioned, whose world share rose by between 4% (Czech Republic) and close to 20% (Poland). Mention should also be made of the upswing in Slovenia, which has boosted scientific production by 60% in five years.

An analysis of scientific production by discipline shows marked differences between countries in terms of positioning and specialization (Table 7). Overall, it shows a dearth of scientific production by the new Member States in medical research and basic biology, with a more marked contribution to world science in terms of chemistry, physics and mathematics.

In terms of technological production, Germany is far ahead of the other European countries, with an 18% share of European patents in 2001 (Table 8). Only two other countries, France and the UK, can boast a share of more than 5%. Taken together, France, Germany and the UK file more than 70% of the patent applications from the entire EU and thus technological production is to a large extent concentrated in these three countries. Next in line is Italy, with a share of over 3%.

Among the EU15 Member States, six stand out for having achieved remarkable growth in technological production: Finland, Greece, the Netherlands, Portugal, Spain and especially Ireland. The share of the latter more than doubled between 1996 and 2001. What about the then-candidate states? While their share of European patents remained extremely low in 2001, there were signs of growth in some of them, particularly the Czech Republic and Poland. Although the functioning of the intellectual property systems of the Eastern European countries has already been aligned on the system of the European

**Figure 4**  
SHARE OF EUROPEAN PATENTS, EU15 AND USA, 1990–2001



Sources: INPI and OEB data, OST treatments.

Patent Office to a large extent, there is still a long way to go to make local actors aware of the strategic dimensions of industrial property. It will be interesting to monitor patent trends in the new Member States to ascertain how

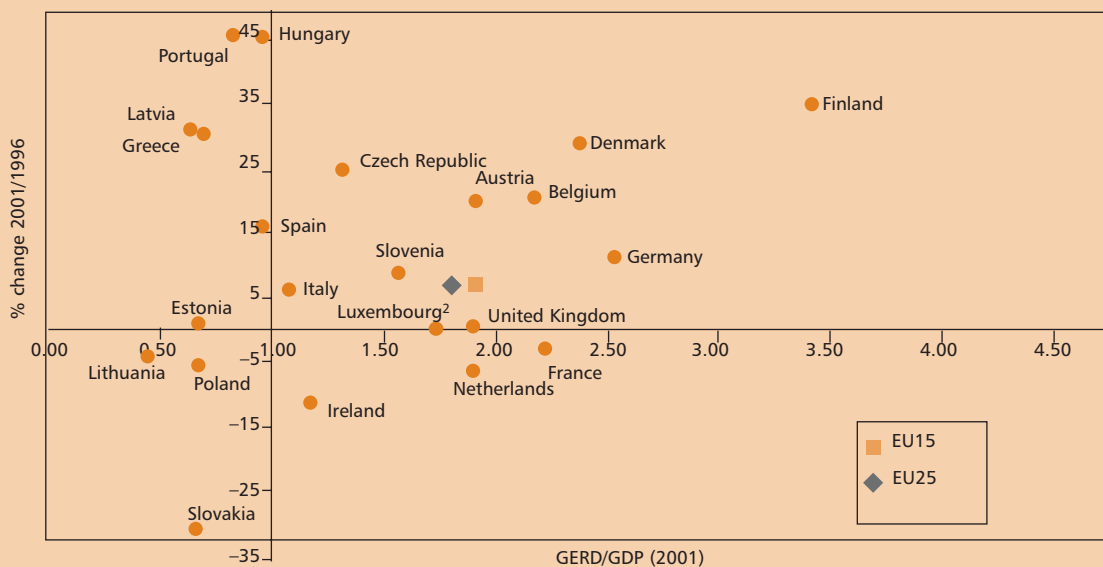
the countries are developing and establishing their own technologies in the European area.

**CONSIDERABLE HUMAN POTENTIAL**

The European Research Area boasted nearly 15 million students enrolled in higher education at the Master’s and Doctoral levels in 2001 (Table 9). Close to 3 million of these students were being educated in the new Member States. Between 1998 and 2001, the total number of students in Master’s and Doctoral programmes increased by 4% in the 15-member EU but by as much as 10% in the 25-member EU – evidence of substantial growth in the new Member States. Whereas student numbers remain stable in France and Germany, they have grown by between 30% and 50% in the new Member States.

The 25-member EU produced more than 80 000 PhDs in 2001, nearly 6 000 of which were awarded in the new Member States. There was an overall increase of 20% for the entire EU25 between 1998 and 2001. In the EU15 countries, close to 40% of PhD holders are

**Figure 5**  
GERD/GDP RATIO IN EU25,<sup>1</sup> 2001, AND CHANGE, 1996–2001



Notes: 1 Excludes Cyprus and Malta. 2 Data from 2000.

Sources: OECD (Main S&T Indicators) and EUROSTAT data, OST treatments.

**Table 6**  
SHARE OF EU25 COUNTRIES IN WORLD  
SCIENTIFIC PUBLICATIONS, 1996 AND 2001\*

Country/zone	World shares (%) of scientific publications		Change 2001/1996 (%)
	1996	2001	
Germany	6.8	7.0	+4
France	5.4	5.1	-5
United Kingdom	8.2	7.5	-8
Italy	3.3	3.5	+5
Spain	2.1	2.5	+19
Netherlands	2.0	1.9	-8
Greece	0.4	0.5	+28
Belgium	1.0	0.9	-1
Portugal	0.2	0.3	+68
Sweden	1.5	1.5	-2
Austria	0.6	0.7	+13
Denmark	0.7	0.7	0
Finland	0.7	0.7	+5
Ireland	0.2	0.3	+12
<b>EU15</b>	<b>33.3</b>	<b>33.4</b>	<b>0</b>
Poland	0.9	1.0	+19
Czech Republic	0.4	0.4	+4
Hungary	0.3	0.4	+11
Slovakia	0.2	0.2	-20
Slovenia	0.1	0.2	+60
<b>EU25</b>	<b>35.3</b>	<b>35.7</b>	<b>+1</b>
<b>World total</b>	<b>100.0</b>	<b>100.0</b>	<b>0</b>

\* Calculated on the basis of the fractional principle as the percentage of the scientific publications or citations recorded in the SCI 'expanded' database produced by ISI (Institute for Scientific Information - Thomson Scientific, Philadelphia, USA). Indicators are based on three years' averaging. Countries that published fewer than 400 publications in 2001 are not included.

Sources: ISI data, OST computing.

women but this percentage varies from country to country: for example, the figure is as high as 51% in Italy but only 31% in the Netherlands. Overall, the new Member States tend to have a higher proportion of women among PhD holders.

In the EU25, there were nearly 2 million full-time-equivalent (FTE) workers in the R&D sector in 2001. This number increased by 15% between 1996 and 2000. One million were working as researchers in 2001, a 20% increase over 1996 (Table 9). These increases were concentrated chiefly in the 15 Member States of the time, especially Spain

and the UK, and in the private sector. Growth was smaller in the new Member States, where the ratio of research staff to the working population was lower than the European average (5.2 per 1,000). There is therefore considerable scope for expansion in the new Member States.

In a nutshell, the population of future young researchers and of researchers is growing in the EU. Nevertheless, there are two disturbing factors: the disaffection with science among young people and the threat the brain drain poses to the new Member States, including at the intra-regional level. Countries will have to build up their national resources. Since women represent just one-third of European researchers in the public sector and one-sixth in the private sector, their access to scientific careers will also be a major challenge in the coming years.

Strengthening R&D potential will call for political responses at both the national and EU levels. The European Research Area must offer an environment that can hold its own against international competition.

### A STRONGER CAPACITY FOR INTRA-EUROPEAN COOPERATION

The heterogeneity of the European Research Area makes it essential to have powerful tools which contribute to its cohesion. Such tools have existed for a long time. They were developed within the framework of the EU or that of intra-European cooperation between states: Framework Programmes for R&D, the Eureka initiative, the European Space Agency (ESA), major European initiatives such as the European Organization for Nuclear Research (CERN) and so on. All levels of action are concerned: training, researcher mobility, the implementation of S&T projects, access to major facilities, and cooperation between industrialists. For the most part, these tools have proved effective.

In the field of training, for instance, more than 110 000 European students were given the opportunity to pursue their tertiary studies abroad within Europe in 2000 under the European Union's Erasmus programme. The number of Erasmus fellowships increased by 70%

between 1995 and 2000. Obviously, student flows are not evenly distributed between countries. The UK remains the leading host country, with 20% of student intake in 2000. However, Spain is now proving a serious challenger to France and Germany. The new Member States send more students abroad than they host. Student mobility, however, may be compounding brain drain from the new Member States, which are already suffering from a serious shortage of scientific personnel. Retaining young researchers, or ensuring they return to their countries of origin, is a major challenge for these

countries but one that will only be met if working conditions at home are excellent and competitive.

As young scientists embark on scientific careers, the fellowship scheme of the Framework Programme, which goes by the name of Marie Curie fellowships, is intended to facilitate student mobility within the EU. The numbers involved are however still small: there were fewer than 3 000 beneficiaries under the fifth Framework Programme (from 1998 to 2002), with wide disparities between countries. These efforts are clearly insufficient and, although precise data are lacking, there are signs

**Table 7**  
**SHARE OF EU25 COUNTRIES IN WORLD SCIENTIFIC PUBLICATIONS, 2001\***  
**By discipline**

Country/zone	World shares (%) of scientific publications per discipline								Total
	Basic biology	Medical research	Applied biology-ecology	Chemistry	Physics	Astro and geo-sciences	Engineering	Mathematics	
Germany	6.8	7.4	5.4	7.6	8.4	6.2	5.9	7.1	7.0
France	5.3	5.1	4.4	5.2	5.7	5.5	4.2	7.8	5.1
United Kingdom	7.8	9.7	6.8	5.4	5.1	8.2	7.2	5.1	7.5
Italy	3.5	4.0	2.3	2.9	4.0	3.8	3.2	4.1	3.5
Spain	2.5	2.4	3.3	3.1	2.1	2.5	1.9	3.6	2.5
Netherlands	2.0	2.4	1.8	1.3	1.3	2.0	1.6	1.3	1.9
Greece	0.3	0.6	0.5	0.5	0.5	0.7	0.8	0.7	0.5
Belgium	1.0	1.1	1.0	0.8	0.9	0.8	0.8	1.0	0.9
Portugal	0.3	0.2	0.4	0.5	0.4	0.4	0.5	0.5	0.3
Sweden	1.7	1.9	1.6	1.1	1.2	1.4	1.2	0.9	1.5
Austria	0.7	1.0	0.6	0.6	0.6	0.6	0.5	0.7	0.7
Denmark	0.9	0.9	1.1	0.4	0.6	1.0	0.5	0.5	0.7
Finland	0.8	1.0	1.0	0.5	0.5	0.8	0.6	0.5	0.7
Ireland	0.3	0.3	0.4	0.2	0.2	0.2	0.2	0.3	0.3
<b>EU15</b>	<b>33.7</b>	<b>37.9</b>	<b>30.5</b>	<b>30.0</b>	<b>31.4</b>	<b>34.0</b>	<b>29.2</b>	<b>33.9</b>	<b>33.4</b>
Poland	0.7	0.5	1.1	1.9	1.7	0.8	1.1	1.5	1.0
Czech Republic	0.4	0.2	0.9	0.7	0.5	0.4	0.3	0.7	0.4
Hungary	0.4	0.3	0.5	0.6	0.4	0.2	0.3	0.9	0.4
Slovakia	0.2	0.1	0.4	0.3	0.2	0.1	0.1	0.3	0.2
Slovenia	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.3	0.2
New Member States	1.9	1.2	3.1	4.0	3.2	1.8	2.2	3.9	2.3
<b>EU25</b>	<b>35.6</b>	<b>39.1</b>	<b>33.6</b>	<b>34.0</b>	<b>34.5</b>	<b>35.8</b>	<b>31.4</b>	<b>37.9</b>	<b>35.7</b>
<b>World total</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

\* Calculated on the basis of the fractional principle as the proportion of the publications or citations recorded in the SCI 'expanded' database produced by ISI (Institute for Scientific Information – Thomson Scientific, Philadelphia, USA). Indicators are based on three years averaging. The countries which published fewer than 400 publications in 2001 are not included.

Sources: ISI data. OST treatments.

**Table 8**  
**SHARE OF SELECTED EU25 COUNTRIES IN**  
**EUROPEAN PATENTS, 1996 AND 2001\***

Country/zone	World shares (%) of European patents		
	1996	2001	Change 2001/1996 (%)
Germany	17.7	17.9	+1
France	7.1	6.1	-14
United Kingdom	5.8	5.3	-8
Italy	3.3	3.1	-4
Spain	0.6	0.7	+16
Netherlands	2.2	2.5	+11
Greece	0.0	0.1	+17
Belgium	1.1	1.1	-3
Portugal	0.0	0.0	+25
Sweden	2.1	2.2	+5
Austria	1.0	0.9	-6
Denmark	0.8	0.8	-1
Finland	1.1	1.2	+11
Ireland	0.1	0.2	+137
<b>EU15</b>	<b>43.0</b>	<b>42.2</b>	<b>-2</b>
Poland	0.0	0.1	+54
Czech Republic/Slovakia	0.1	0.1	0
Hungary	0.1	0.1	+57
<b>EU25</b>	<b>43.3</b>	<b>42.5</b>	<b>-2</b>
<b>World total</b>	<b>100.0</b>	<b>100.0</b>	<b>0</b>

\* Indicators are calculated on the basis of the fractional principle and are based on three years averaging. The countries that registered fewer than 50 European patents in 2001 are not shown in the table. Given the difficulty in differentiating with certainty the findings for the Czech Republic and Slovakia, the two countries have been assessed and are presented together in this table.

Sources: NPI and EPO data, OST computing.

that young researchers often prefer North America to Europe for their postgraduate studies. Lastly, the question of a common status for European researchers is on the political agenda as a means of fostering intra-European mobility. It remains to be seen whether Member States are sincerely in favour of it or whether they prefer to play their individual cards in these times of intense international competition.

The Framework Programme remains the major instrument for cooperation among European laboratories. Between 1998 and 2002, the fifth of these programmes

– which associated the then-candidate countries – generated over 11 000 projects involving participation by more than 70 000 teams from various public and private laboratories. Six teams participated in a project on average. This sort of tool certainly facilitates European cooperation, yet the overall picture must be qualified by two comments. First, industrialists tend to disengage from these projects, considered too burdensome in terms of return on investment and as not always tying in with industrialists' own international strategies. Second, the financing of research by these projects constitutes only a small part of laboratories' expenditure. Overall, the funding of the Framework Programme represents only 3.5% of European public finance, although the proportion is as high as 26% for Greece and 11% for Ireland. In the latter countries, the Framework Programme is an essential source of funding for R&D, which is also a weak point.

Here again, concentration is a major feature. Some 40% of participation in the Framework Programme involves British, French and German teams, thereby reinforcing collaboration between the laboratories of the larger countries. There was little cooperation with the then-candidate countries under the fifth Framework Programme, the ten new Member States representing only 5% of participation. Yet cooperation with the new Member States began as early as 1992 under the third Framework Programme through a specific programme. The fourth Framework Programme also enabled some 30 'centres of excellence' to be funded in a number of accession countries. The Framework Programme is just one among many research-financing windows in Europe, of which there are more in some countries than in others. It is an open question whether the Framework Programme can remain the only means of funding research at the European level. Major projects like the proposed European Research Council are in any case currently under discussion.

But will the Framework Programme, as it is presently structured, or any other mechanism, succeed in strengthening research in those countries where it is undeveloped? Competition is intense for a limited number of funded

projects, a situation that could well lead to proposals from these countries' teams being rejected for the simple reason that they are too numerous to be taken on board.

In addition to the Framework Programme, there are other major non-Community European bodies, such as CERN and ESA mentioned earlier, and the European Synchrotron Radiation Facility (ESRF), which are the mainstays of major infrastructure for research in Europe. With a combined annual budget of approximately € 3.5 billion, these bodies are also exposed to broad international cooperation and help to structure R&D in Europe.

Through these mechanisms, scientific cooperation has certainly been strengthened within the EU. This can be measured by the share of scientific publications co-signed by teams from various countries of Europe. In 2001, the contribution of individual countries to international co-publications with another member of the EU ranged from 45% for Germany to nearly 75% for Portugal. European co-publications have been rising significantly, especially for the countries where scientific production is growing, as in the case of Portugal. For the EU15 countries, the proportion of co-publications produced with US laboratories is now considerably lower than that of European co-publications.

There were still few co-publications by the EU15 countries with the new Member States in 2001. Relations with neighbouring states are a major factor here: 10% and 12% of the co-publications involving Austria and Finland respectively were being produced with one of the future Member States. By contrast, in Spain and the UK, co-publications with the new Member States represented less than 5% of the total. Evolving trends in co-publication between the 'old' and 'new' Member States will be a good indicator of whether the European Research Area is truly expanding.

### (R)EVOLUTION IN RESEARCH SYSTEMS IN THE NEW MEMBER STATES

The reasons for the gap between the old and new EU Member States are largely systemic. Since the collapse of the Soviet bloc in 1989, institutional reform has been

**Table 9**  
STUDENTS AND RESEARCHERS IN EU25 COUNTRIES, 2001

Country/zone	Enrolled students in Master's and PhD courses (thousands)	Number of graduated PhDs	Number of FTE researchers (thousands)
Germany	2 084	24 796	264
France	2 032	10 404	177
United Kingdom	2 067	14 147	158
Italy	1 812	4 044	66
Spain	1 834	6 453	80
Luxembourg <sup>1</sup>	–	–	2
Netherlands	504	2 533	45
Greece	–	–	15
Belgium	359	1 317	32
Portugal	388	2 791	18
Sweden	358	3 388	46
Austria	290	1 871	–
Denmark	191	795	19
Finland	280	1 797	37
Ireland	167	572	8
<b>EU15<sup>2</sup></b>	<b>12 075</b>	<b>74 908</b>	<b>987</b>
Poland	1775	4 400	57
Czech Republic	260	1 066	15
Hungary	331	793	15
Slovakia	144	532	10
Lithuania	103	37	8
Latvia	136	261	3
Slovenia	91	298	4
Estonia	58	149	3
<b>EU25<sup>2</sup></b>	<b>14 992</b>	<b>81 657</b>	<b>1 102</b>

#### Notes

1 Data from 2000.

2 The totals exclude EU countries for which data are unavailable or insignificant.

Sources: OECD (*Main S&T Indicators*), OECD *Education at a Glance* and EUROSTAT data, OST estimations and computing.

initiated widely in most of the new Member States. National systems have been either entirely rebuilt or remodelled and all have been greatly transformed over the past 15 years, even if this restructuring is still work in progress. The role and place of science academies, which used to bear sole responsibility for basic research in the Soviet era, has changed. Conversely, the role of universities has generally been strengthened and

## *R&D in Central and Eastern Europe: change is the only option*

In the 1990s, Central and Eastern European countries had to contend with major budgetary difficulties when it came to financing R&D. A restructuring of the systems inherited from the Soviet era went hand in hand with a reduction in funding of R&D as a percentage of GDP, at least during the first half of the decade. Although the decline seems now to have been halted, the GERD/GDP ratio remains weak in most of these countries, ranging between 0.4% and 0.8% of GDP, and is much lower than the average of the 15-member EU (1.9% in 2001), itself considered insufficient. The private sector's share in funding R&D remains negligible.

The Central and Eastern European countries originally had monolithic and hierarchical national R&D structures, the central feature of which was an academy of sciences. The research system was consistent with the Soviet model: on the one hand, a technological development sector in the state industrial institutes and, on the other, an academy of sciences responsible both for fundamental research and for the implementation of national science policy. Those structures were changed during the transition period, rather abruptly in some countries, and aligned more on the Anglo-Saxon model for the organization of research, a move fairly consistent with the recommendations of the EU and the OECD. Research was then gradually transferred to the universities and funded by various agencies, some of which had specific objectives. Governments took over control of the system from the academies and framed national

science policies, which were more effectively brought into line with the international context as the prospect of joining the EU became more compelling.

The R&D personnel factor remains crucial for the future of national research and innovation systems. Overall, in the countries of Central and Eastern Europe, the number of researchers per 1 000 in the labour force is well below the EU average of 5.2 per 1 000. It is a major asset for the countries, however, that researchers are usually highly qualified. This has enabled them to maintain excellence. Unfortunately, because of the economic difficulties encountered during the transition to a market economy, infrastructure is obsolete and salaries pitiful. This not only undermines the attractiveness of local public research but is also nourishing both internal brain drain (to other branches) and external brain drain (abroad).

Even more disastrous for the younger generations is the demotivating effect of a combination of inadequate pay, outdated laboratory equipment and isolation brought about by the break-up of research teams. Increasingly, young students are rejecting activities that do not guarantee them the quality of life to which they legitimately aspire. An adverse consequence of this has been the ageing of the research population, markedly so in some countries. A number of countries are conscious of the problem (particularly the Baltic countries) and are beginning to introduce strategies to lure researchers back from overseas, such as by offering them a level of responsibility which would probably elude them abroad.

As might be expected from the trends in GERD and the number of researchers, scientific production in Central and Eastern European countries is small, having declined gradually during the early years of transition and even throughout the decade in the case of Bulgaria. The drop has now levelled off, with some countries even recording a rise, in particular Slovenia.

The growth in scientific co-publications shows the speed with which the research teams in these countries have opened up to international cooperation. This has certainly been greatly facilitated by the forced march towards membership of the EU, as can be seen from the prominent place of the large European countries among initial partners, with Germany topping the list. The anticipated rise of the new Member States to prominent positions in the Framework Programmes for community research should help enhance this European partnership.

Chemistry, physics and mathematics are the fields in which researchers from the Central and Eastern European countries publish most; they are also the most visible fields. By contrast, all the life science disciplines are still poorly developed in the new EU Member States. Belonging to the European Research Area, whether or not it is effective or still in the planning in 2007, will probably prompt national research to focus on certain pre-eminent disciplines and the structuring of a network of laboratories around a few selected centres with a high international profile that are likely to attract private investment and foreign scientific partnership.

In the sphere of technology, Central and Eastern European countries are conspicuous by their absence when it comes to the filing of patent applications.

Structures for the protection of intellectual property did not exist 15 years ago; entry into the EU has obliged these countries to adopt reforms bringing them into conformity, eventually, with international regulations. Furthermore, rather than giving rise to the creation of new technologies, economic specialization in these countries in terms of R&D tends to favour importation of new technologies, followed by implementation of these in the traditional sectors of the national production system.

Whereas the national research and innovation systems of the countries in the region are at a serious historical disadvantage in the face of international competition, there is every reason to hope for improvement. There is first of all their remarkable, demonstrated ability to adapt national structures within the space of a few years to the widely globalized environment of S&T. Moreover, the relocation of industrial production has released an increasing flow of foreign direct investment, a trend that is no doubt going to amplify in the coming years and which may offer a real opportunity to attract R&D. Last but not least, effective integration into the EU should enable these countries to gain access to structural funds and ease the financial burden of the structural reforms undertaken since the transition got under way. If these funds are used appropriately, they will serve primarily to improve essential infrastructure, make sound investment for the future and overcome the most serious handicaps.

It is clear that those countries with a political leadership that succeeds in defining and implementing S&T priorities – and keeping to them – will be best placed to attract foreign investment and partnerships.

## *Is the European Union's objective over-ambitious?*

At the Lisbon European Council in March 2000, the heads of state and government assigned to the EU the objective of becoming, by 2010, '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'. In 2002, at the Barcelona European Council, they agreed that spending on R&D in the EU should be increased and approach 3% of GDP by 2010, against the 2002 figure of 1.9%. Not all the present Member States, including the new ones, are expected to be able to achieve this objective individually by 2010, but all must contribute to it. Growth must be achieved by increasing R&D funding by businesses, in order to bring it up to two-thirds of total R&D investment, a proportion which has already been reached in some European countries.

Given the 25-member EU's average of 1.8%, is this 3% target still realistic for all European countries?

Only in two European countries in 2001 did R&D expenditure exceed the 3% target: in Sweden (4.27% of GDP) and Finland (3.42%). Both these countries have an exceptionally high share of corporate funding (more than 70% of R&D expenditure); corporate funding represents 3% of GDP in Sweden and 2.4% in Finland. Public sector funding also represents a higher share of GDP than that of the EU countries as a whole but somewhat closer to other countries such as France.

Are Sweden and Finland a model for the other European countries? Taking the example of Finland, the steep growth in GERD in the 1990s was mainly

accounted for by the electronics industries. Today, these industries represent more than 50% of business expenditure. While Finland succeeded in specializing in a niche sector on an international scale, its exceptional position is based on a very small number of industries and was secured in a context that was highly profitable at the time for that sector. Even if this model might conceivably be applied to other similar-sized countries, such as some of the new EU Member States, it cannot be applied across the board in Europe, where research is much more diversified.

Apart from Sweden and Finland, only four countries in the EU spend more than 2% of GDP on R&D: Germany, Denmark, France and Belgium, in decreasing order. The GERD of all these countries represents more than 60% of the total for the 15-member EU. The 3% target is therefore ambitious, even over-ambitious, for the entire 25-member EU, since it requires many countries to make up a gigantic shortfall immediately.

Lastly, the decline in the EU's attractiveness for investment in R&D by the private sector is becoming a major concern. In recent years, the research laboratories of multinational firms have tended to locate in the USA. Asian countries such as China, India, and the Republic of Korea have also begun to compete internationally. To remain competitive in the technological sphere, European countries must therefore develop basic research. The question of their scientific expertise, greatly dependent on the quality of education and on human resources in the public sector, will be crucial.

universities have been provided with greater resources. However, long stifled by the science academies under the Soviet system, universities now have to catch up and building scientific excellence takes time. Moreover, the massive spread of higher education has led to a great demand for teaching; this is the main obstacle to the development of university research.

Although it may be an asset for the new Member States to be focusing on basic research in universities once more, the benefits will only emerge in the long term. In the meantime, public authorities will need to bolster the university sector over a prolonged period.

As for industrial research, the transformation of heavy industries from the Soviet era into modern industries has been sluggish. Once centralized, the demand for industrial development has now given way to the harsh reality of competition on the world market. Using the example of Hungary, businesses financed less than 40% of GERD in Hungary in 2001, as against 56% on average for the EU15; and whereas BERD represents 1.26% of GDP in the EU15, it accounts for less than 0.30% in Hungary. In several countries, the growth in corporate funding for research is trailing behind growth in public funding, a trend that is cause for concern, particularly in relation to the target of devoting 3% of GDP to R&D set by the European Council.

Some hope may come from the direct foreign investment flowing into the new Member States but this cannot offset the low level of industrial funding for research. The interest shown by European and US firms seems primarily driven by the desire to establish themselves in a low-cost area for production and to position themselves in expanding markets. These ventures are rarely intended to make use of local S&T expertise. However, foreign investment has provided the momentum for the development of a number of technological niches (such as pharmaceuticals and motor vehicles in Slovenia, information and

communication technology in Estonia and lighting in Hungary).

In summary, whereas the new Member States are trailing in industrial research, they have a strong tradition in academic research to fall back on, even though this sector lacks resources.

### THE FUTURE: AN OPEN BOOK

The state of R&D in the EU is a mixed bag: the heavyweights, such as France, Germany and the UK, are experiencing stagnation, whereas the new Member States are continuing to trail behind. Should we be pessimistic about the chances of achieving a European Research Area?

The main issue is whether countries can overcome economic hurdles and find the political capacity to defend research in an often difficult context. Efforts by the new – but also the older – Member States will be hindered by financial restrictions resulting from the need to control budget deficits in countries wishing to join – or remain in – the euro zone. The over-ambitious target of 3% of GDP will not be achieved by 2010 in the 25-member EU and will have only a slight chance of being achieved in the 15-member EU. The entry of ten new Member States should prompt a fresh look at Europe's objectives and needs. Where should efforts be focused and where do priorities lie? Should disparities be allowed to grow? Should centres of excellence be promoted? Should countries be provided with back-up whenever integration is not possible? Clearly, there is broad scope for reflection. The first move of this new EU should be to devise a major common project for R&D.

The task may be made easier by the fact that eight out of ten citizens in the new Member States see science as an asset. We must not disappoint these new citizens of the EU; rather, we should see to it that R&D contributes to their economic development and social well-being.

## REFERENCES AND FURTHER READING

- Barré, R. and Esterle, L. (2002) *Indicateurs de sciences et de technologies*. Rapport de l'Observatoire des sciences et des techniques. Editions Economica.
- Cadiou, Y. and Esterle, L. (2002) *Scientific Profile Activities in CEEC: A Comparative Study Based on Scientific Publication Indicators and International Co-publications*. Report prepared for the UNESCO Regional Bureau for Science in Europe (ROSTE).
- Esterle, L. and Papon, P. (2002) Le chantier de la recherche européenne. *La recherche*, 351, p. 66.
- Esterle, L. and Filliatreau, G. (2004) *Indicateurs de sciences et de technologies*. Rapport de l'Observatoire des sciences et des techniques. Editions Economica.
- European Commission (2002) *R&D and Innovation statistics in Candidate Countries and the Russian Federation*. Office for Official Publications of the European Communities, Luxembourg.
- (2001a) *Innovation Policy Issues in Six Candidate Countries: The Challenge*. Available at [www.cordis.lu/innovation](http://www.cordis.lu/innovation).
- (2001b) *Towards a European Research Area: Key Figures 2001*. Special Edition: Indicators for Benchmarking of National Research Policies. Office for Official Publications of the European Communities, Luxembourg.
- (2003a) *Candidate Countries Eurobarometer*. CC-EB 2002.3 on Science & Technology, DG Press and Communication. Available at: [europa.eu.int/comm/public\\_opinion](http://europa.eu.int/comm/public_opinion).
- (2003b) *She Figures 2003: Women and Science Statistics and Indicators*. EUR 20733. Office for Official Publications of the European Communities, Luxembourg.
- (2003c) *Science and Technology Indicators*. Third Report. Office for Official Publications of the European Communities, Luxembourg, Available at [www.cordis.lu/indicators](http://www.cordis.lu/indicators).
- OST (2004) *Les systèmes nationaux de recherche et d'innovation du monde et leurs relations avec la France. La Hongrie, 2003; la République tchèque, 2003; la Pologne, 2004*. Observatoire des sciences et des techniques, Paris. Available at: [www.obs-ost.fr](http://www.obs-ost.fr).
- UNESCO (2001) *Reconstruction of Scientific Cooperation in South-East Europe*. International Conference of Experts. Proceedings of meeting hosted by UNESCO Regional Bureau for Science in Europe (ROSTE), Venice, Italy, 24–27 March 2001.

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