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in support of the Commission Communication

MORE RESEARCH FOR EUROPE
Towards 3% of GDP

{COM(2002)499 final}

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1. INTRODUCTION

This annex to the Communication "Research for Europe - Towards 3% of GDP" offers background information on the role of R&D in the knowledge-based economy and background data (mainly in graphic format) on the EU's under-investment in R&D, sectoral aspects and the situation of Member States and candidate countries.

2. THE ROLE OF R&D IN THE KNOWLEDGE-BASED ECONOMY

While knowledge has always been an important element of economic activity, three unprecedented patterns allow us to describe today's advanced economies as being "knowledge-based":

– The fast growing accumulation of and reliance on formal scientific and technical knowledge affecting all sectors of the economy, with ever higher S&T content embedded in products and services and, as a consequence, the need for more and better qualified human resources;

– The availability of powerful technical means for the diffusion and use of such knowledge, and for more efficient economic activity generally, thanks to the new information and communication technologies (ICT).;

– The increasing pace of trade liberalisation and flows of good and services, pushing economies such as ours to focus on more knowledge-intensive activities.

Hence, R&D as a major generator of knowledge becomes increasingly important, both as a driver of economic productivity and growth and as a means to support public policy objectives in areas such as public health, food safety and sustainable development. However, R&D is a necessary but not a sufficient factor to create growth and employment, since its effect on the economy depends on the economy's capacity to turn new knowledge into innovation. Such capacity is closely linked to the framework conditions in which companies operate.

2.1. R&D and the competitiveness of enterprises

Ninety years after Schumpeter placed innovation at the core of the competitiveness of enterprises, its key role is widely acknowledged in economic research, and so is the importance of R&D as its main source. Innovation is the key for enterprises to secure a competitive advantage, either through new and improved products or services or through more productive processes or organisation. R&D is an essential input for technological innovation[1], either directly as the internal source of the new knowledge on which innovation relies, or indirectly by providing the firm with the knowledge and skills enabling it to exploit externally-produced S&T. Econometric research confirms the positive effect of R&D on firms' competitiveness. For example, a recent study based on a large sample of European and American enterprises confirmed that firms with higher R&D expenses outperformed others

[1] Hereafter referred to as "innovation"

both in productivity gains and in the growth of their revenues[2]. Empirical work typically finds that a given increase in R&D spending leads to a 10 % to 30 % higher increase in output[3].

2.2. R&D and growth of productivity and production

Numerous economic studies have assessed the contribution of technical progress to productivity gains and economic growth. Although economists converge in recognising an important role to technical progress, estimates of its contribution to gowth vary depending on the models, hypotheses and definitions used. A recent analysis of the correlation of growth and productivity gains with various innovation-related factors across European countries, confirms the significant positive relation between some R&D indicators, productivity and growth at EU level. This study finds notably that the indicator most highly correlated with both productivity gains and growth is the share of firms with continuous research expenditure in a country[4].

2.3. R&D and employment

Most studies show that R&D-based innovation has a positive effect on the overall volume of employment on the long run[5]. Moreover, R&D brings significant benefits in terms of the quality of employment. R&D and innovation increase the technology content of products and processes in all sectors of the economy. This leads to a shift in the structure of employment in favour of more qualified workforce, which benefits overall from more stable jobs and better pay. R&D-based innovation also contributes to raising prosperity per capita, through a higher variety of goods and services and lower real prices thanks to increases in productivity.

In the long term, in a context of full employment (once the Lisbon objectives are reached) and of ageing population in Europe, R&D may be valued less for creating employment than for driving productivity growth and thus allowing for the continuing increase of wealth and living standards.

2.4. R&D and international diffusion of technology

R&D gives rise to particularly high cross-country spill-overs, due to the intangible and potentially ubiquitous nature of formal knowledge such as scientific publications and patents. Yet there is little room for free-riding as a company without a proper S&T base will not be able to exploit the knowledge produced by others. A recent analysis of 16 OECD countries confirmed that the positive impact of foreign R&D on productivity is higher in countries where the domestic business R&D intensity is high[6].

Another aspect to take into account is the increasing international mobility of the investments of multinational companies. R&D performed by subsidiaries of foreign

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2 Wieser R., *The impact of R&D on Output and Productivity, Background report to the European Commission*, cited in the *European Competitiveness Report 2001,* op. cit.

3 As remarked for example by the Economic Policy Committee *Report on Research and Development*, 10 January 2002

4 *European Competitiveness Report 2001*, op. cit.

5 See for example the recent modelling work by the Institute for Prospective Technological Studies, *Impact of Technological and Structural Change on Employment: Prospective Analysis 2020 - Synthesis Report*, EUR20131 EN, 2001

6 Guellec and Van Pottelsberghe*, R&D and productivity growth*, OECD, 2001

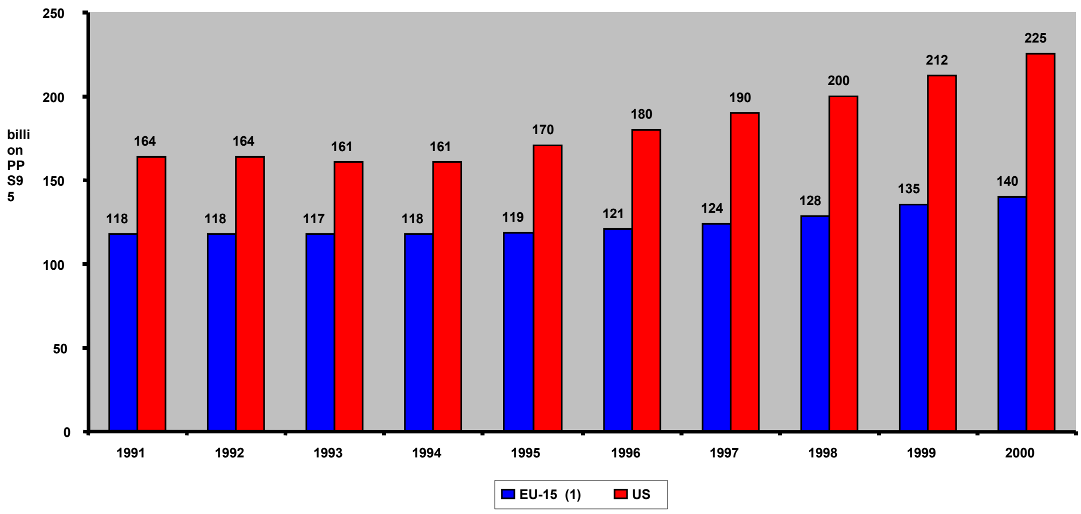
firms exceeds 15 % of manufacturing R&D in Germany, France, Sweden and Finland, as well as in the US. It exceeds 20% in Italy, the Netherlands and Portugal, and 30% in the UK. It reaches even 40% in Spain and 65% in Ireland[7]. Countries are increasingly competing for these resources on the basis of the framework conditions they offer to investors.

3. EUROPE'S DEFICIT IN R&D INVESTMENT

3.1. R&D expenditure, EU and US

Even in purchasing power parity, the gap between the EU and US has been growing continuously and at an accelerating pace since 1995. Its level in 2000 is double that of 1994.

Gross Domestic Expenditure on R&D (GERD) in billions of PPS at 1995 prices

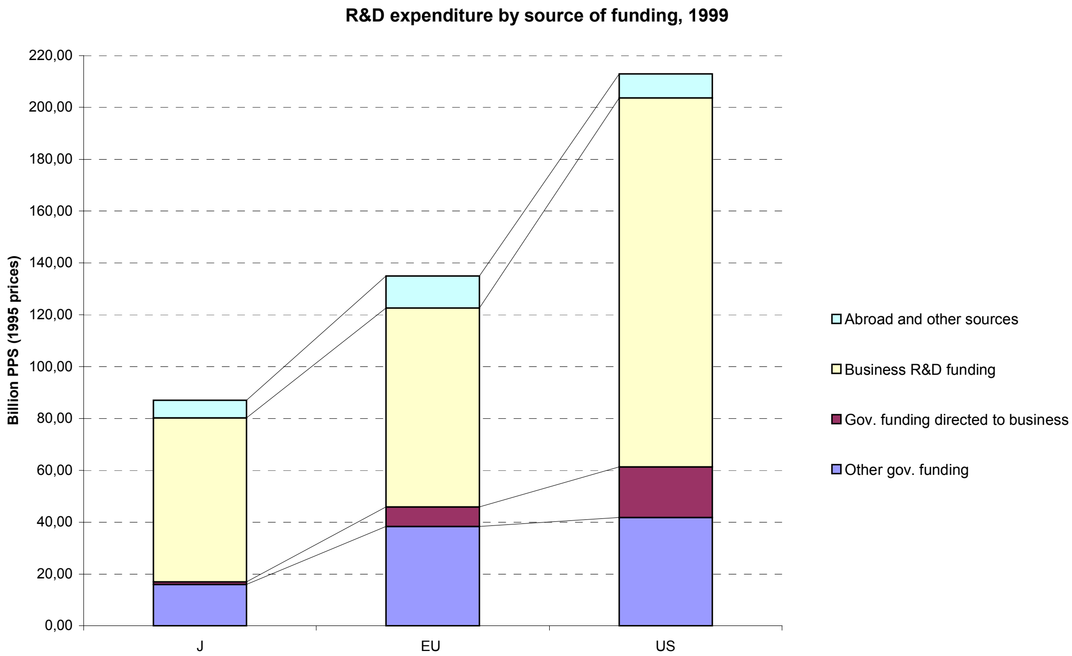


7 *Measuring globalisation - The role of multinationals in OECD economies*, op. cit.

Data: OECD/Eurostat Source: DG Research
Note: EU-15 does not include Luxembourg; US data exclude most or all capital expenditure (2000: forecast)

3.2. R&D expenditure by source of funding at purchasing power parity, EU, US and Japan, 1999

Business-funded R&D is by far the main component of the gap between the EU and US. However, there is also a wide gap in the levels of government funding directed to business, and the share of industrial R&D funded by government remains far higher in the US despite the strong growth of business-funded R&D in recent years.

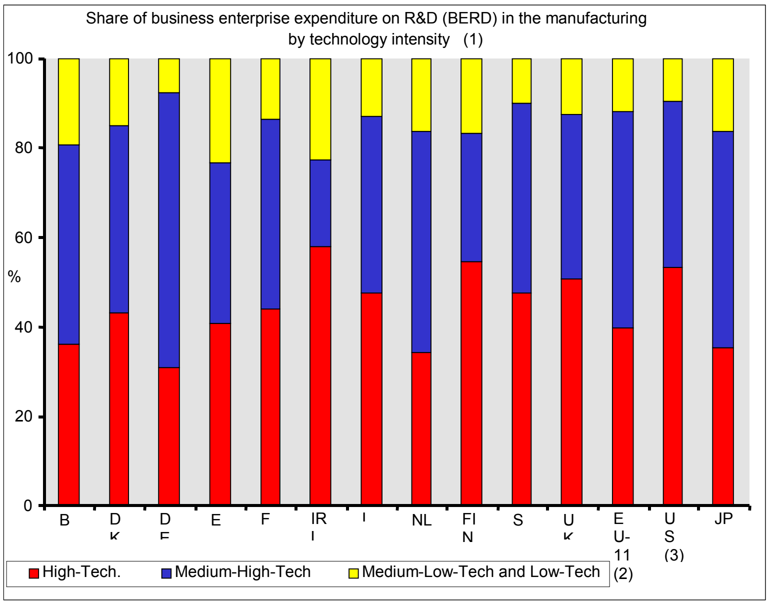


Data: OECD - Source: DG Research

4. STRUCTURE AND R&D INTENSITY OF INDUSTRY IN THE EU AND THE US

4.1. Relative importance of high, medium and low-tech industries in business R&D[8]

Although the structure of manufacturing industry varies widely between countries, it is generally oriented more towards medium-tech sectors in the EU and more towards high-tech sectors in the US.



Notes : (1) I : 1999; B,DK,D,FIN,UK : 1998; E,F,IRL,NL,S,EU-11,US,JP :
(2) EL,L,A,P are not included in EU-11.
(3) US : Ships (Medium-Low-Tech.) are included in other transport (Medium-High-Tech.).

Data: OECD **Source: DG Research**

4.2. Main sectoral differences between the EU and the US

A large part of the difference between the US and the EU is coming from the defence industry and from the sector of information & communication technologies (ICT). These industries are highly R&D intensive. They represent a much larger share of output in the US than in the EU, due to the decline of defence spending in Europe in the 1990s and to the rapid expansion of the ICT industry in the US during the same period.

Government budget appropriations for R&D in the defence sector is five times lower in the EU than in the US at circa 10 vs 50 billion current euros[9]. Recent defence budget increases proposed by the US administration would bring the latter figure close to 54 billion euros by 2003, widening the gap even more. The situation of defence research in the EU needs careful consideration. Some studies indicate that a large proportion of defence R&D could potentially be of dual use and that, reciprocally, civilian technologies can contribute significantly to military

8 The table relates to manufacturing only. The measure of R&D in services raises some methodological difficulties, however, available estimates show a much lower R&D intensity in services in the EU (0.22% of value added) than in the US (0.51%).

9 Source: Eurostat, OCDE

development[10]. This suggests that greater two-way interactions could be encouraged between defence and civilian technologies. The European Parliament has drawn attention to some of these issues in its resolution on defence industries of 13 May 2002.

R&D expenditure in ICT is three times higher in the US than in Europe. A measure of Europe's lagging position is given by the fact that 52% of all OECD investment in ICT research is concentrated in the US, vs 22% in Japan and only 15% in Europe. The EU's under-specialisation in ICT is particularly worrying, due to the underpinning role of ICT in all fields of science and technology, and to its important impact on productivity gains in all sectors of the economy.

However, it has also been argued that the EU should focus on areas of strength, such as some medium-tech industries and some complex technology systems (transport infrastructures, environmental systems, health systems, food safety systems) where Europe is deemed to hold a competitive advantage[11].

4.3. R&D intensity by sector of industry, EU and US

Research intensity (R&D expenditure as per cent of production) is significantly lower in the EU than in the US in a majority of sectors of manufacturing, including in medium- and low-tech sectors such as e.g. motor vehicles, electrical machinery, metal and mineral products, pulp and paper, etc.[12]. Attempts to measure R&D in the services sector also show a much lower intensity than in the US (see footnote 7).

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10 An external evaluation of the WAEO-sponsored EUCLID and EUROFINDER R&D programmes in 2001 found that 63% of projects had a potential for technology transfer towards the civilian sector, and that 18% had actually benefitted from civilian technology.

11 See IPTS *Technology maps* [ref.]

12 *European Competitiveness report 2001*, op. cit.

5. SITUATION OF MEMBER STATES AND CANDIDATE COUNTRIES

5.1. R&D intensity by country

Both Member States and candidates countries have widely different R&D intensities, ranging from 0.25% in Cyprus to 3.8% in Sweden, the average value being 1.9% for the EU and 1.8% for the EU plus the candidate countries.

Table 1 R&D intensity (gross domestic expenditure on R&D (GERD) as % of gross domestic product (GDP))

Country	R&D intensity (%)for the latest available year (1)
Belgium	1.97 (3)
Denmark	2.07 (3)
Germany	2.52 (3)
Greece	0.67 (3)
Spain	0.97 (3)
France	2.13 (3)
Ireland	1.21 (3)
Italy	1.04
Luxembourg	Na
Netherlands	2.02
Austria	1.86 (3)
Portugal	0.76
Finland	3.67 (4)
Sweden	3.78
United Kingdom	1.86 (4)
EU-15 (2)	1.94
Bulgaria	0.57
Cyprus	0.25
Czech Republic	1.25
Estonia	0.75
Hungary	0.69
Lithuania	0.60
Latvia	0.40
Malta	Na
Poland	0.75
Romania	0.40
Slovenia	1.51
Slovak Republic	0.66
Turkey	0.63
EU15 and candidate countries	*1.76*
United States	2.70 (4) (5)
Japan	2.98

Data: Eurostat, OECD - Source: Eurostat, DG Research

Notes : (1) (1) UK : 2002 ; B, D, E, A, FIN, EU-15 : 2001 ; F, US, JP, LT : 2000; all other countries : 1999. (2) Luxembourg is not included in EU-15. (3) Estimation. (4) Forecast. (5) excludes most or all capital expenditure

5.2. Relative funding of R&D by government and industry, by country

The levels of business funding of R&D vary also considerably among EU countries, although in several countries the business sector is already funding around or above two-thirds of total R&D expenditure: this the case of Finland, Sweden, Germany, Belgium and to a lesser extent Ireland.

Table 2 Gross domestic expenditure on R&D (GERD) financed by government and industry, 1999 or latest available year (1)(2)

Country	GERD financed by industry (%)	GERD financed by government (%)
Belgium	66.2	23.2
Denmark	58.0	32.6
Germany	66.9	30.7
Greece	24.2	48.7
Spain	49.7	38.6
France	54.1	36.9
Ireland	64.1	21.8
Italy	43.0	50.8
Luxembourg	na	na
Netherlands	49.7	35.8
Austria	40.1	40.3
Portugal	21.3	69.7
Finland	70.3	26.2
Sweden	67.8	24.5
United Kingdom	49.3	28.9
EU-15 (3)	56.3	34.2
United States	68.2	27.3
Japan	72.4	19.6

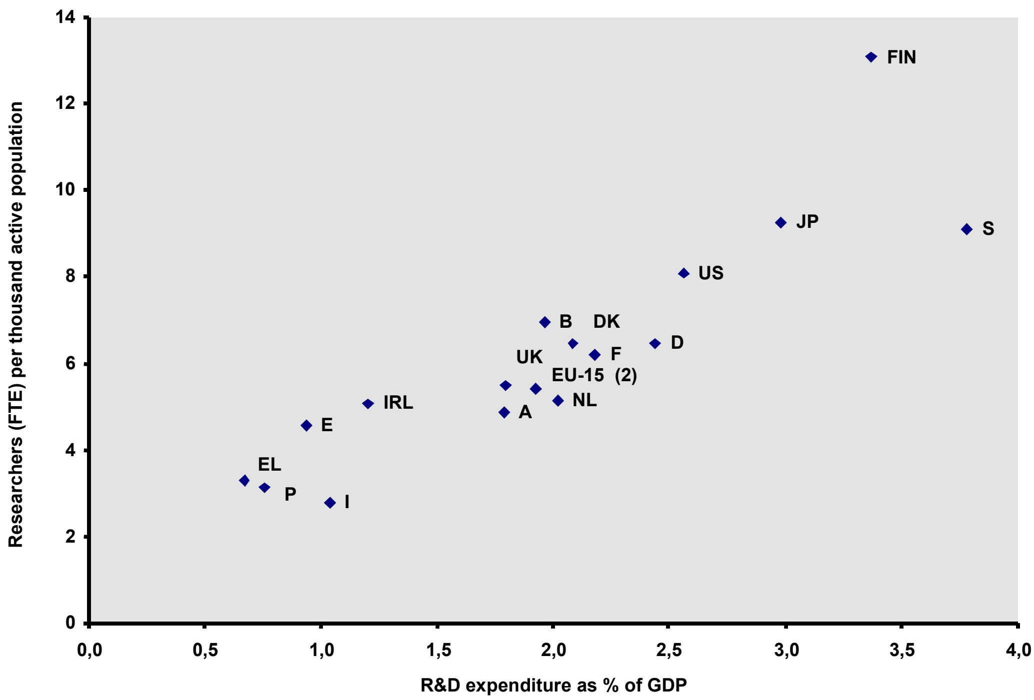
Data: OECD - Source: DG Research

Notes : (1) Sum inferior to 100% due to the category "abroad and others". (2) D, A : 2001; E, FIN, UK, US, JP : 2000 ; I : 1996. (3) Luxembourg is not included in EU-15.

5.3. R&D intensity and human resources intensity in S&T by country

Across the EU, the US and Japan there is a linear relationship between R&D intensity and the share of researchers in the active population, with the latter in the order of five, eight and nine researchers per thousand active population. A major challenge in seeking to raise the level of R&D intensity in Europe is thus to ensure sufficient and high quality human resources.

R&D intensity and human resources intensity in S&T by country, 1999 (1)



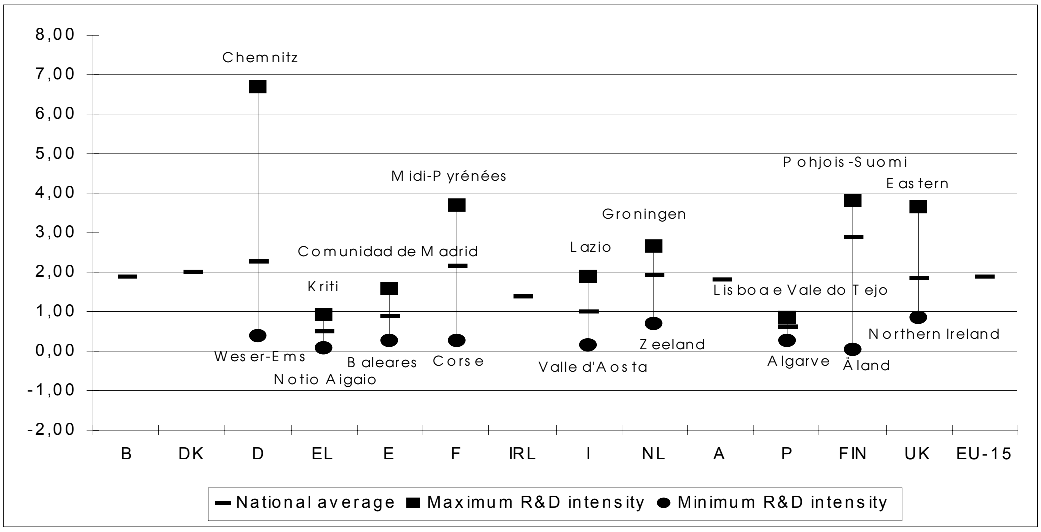
Data : Eurostat/OECD /Countries - Source : DG Research.

Notes: (1) E, FIN, JP : 2000; A, UK : 1998; US : 1997. (2) EU-15 does not include Luxembourg.

5.4. 5.4 R&D intensity by region

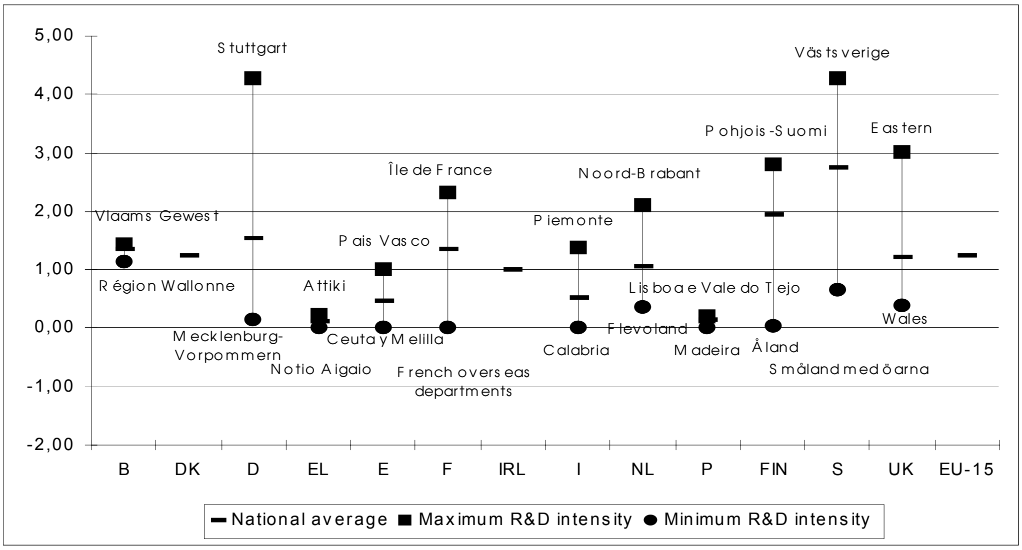
Differences in R&D intensities between Member States at national level mask significantly greater differences between regions inside each country. The objective of convergence between the EU Member States implies specific regional policies with regard to R&D as well as to other policies in order to ensure consistent regional development.

R&D intensity by region: maximum, average and minimum values by country



Notes: I, 1996; D,EL,IRL,P: 1997; All other countries: 1998; Source: Eurostat

Business R&D intensity by region: maximum, average and minimum values by country



Notes: D,EL,IRL,P,S: 1997; B,E,F,I,NL,FIN,UK: 1998; DK: 1999; EU: 2000; Source: Eurostat