CENTER FOR ECONOMIC RESEARCH AND ENVIRONMENTAL STRATEGY
CERES
Athens, Greece

The Impact of R&D State aid and its appraisal on the level of EU research expenditures in the context of the Barcelona European Council Objectives

.

FINAL REPORT

October 2005

Participating Researchers:

Professor Yannis Katsoulacos, Athens University of Economics and Business (Coordinator – Scientific Responsibility for Parts I, II and V)
Professor Lena Tsipouri, University of Athens, Department of Economic Sciences (Scientific Responsibility for Parts III and IV)
Mr. Ken Guy, Wiseguys Ltd (Scientific Responsibility for Part VI)

Maria Koutsodimou (Research Assistant)
Anastasia Matraga (Research Assistant)
Despina Mavri (Research Assistant)

ACKNOWLEDGEMENTS

We would like to acknowledge our debt to Mr. Reinhard Schulte (DG RESEARCH) for many useful comments during the preparation of this report. Thanks are also due to all the Commission officers from DG RESEARCH, DG COMPETITION and DG ENTERPRISE, as well as the members of the Steering Committee, who participated in the meetings in which various versions of the report were presented and provided useful advice. The authors would finally like to thank Victor do Prado - World Trade Organization, Jan Van den Biesen – Philips and UNICE, Emmanuel Leprince - Comité Richelieu, Gerry Shehan – OECD, Alfred Gossner - Fraunhofer Gesellschaft, Munich, Phil Shapira, University of Atlanta and Connie Chang – NIST for valuable information and advice. It goes without saying that the responsibility for any errors or omissions remains entirely ours.

Table of Contents

List of Appendices

PART I

The Importance of R&D and State aid Policy

Section A: Background and Review of Theory and State aid Policy

1. Project Rationale and Objectives: The importance of R&D and public intervention

Main objectives

The main objectives of this study are to describe and analyse:

I. The role State aid to R&D plays in the overall public R&D support context

II. The functional changes of public research establishments (PRE) - universities and public research institutes - in the last decade

III. The public support to R&D measures of the Community's major trading partners

IV. The basis of the various categories of research activities

V. The leverage effect of R&D State aid, in terms of its potential to stimulate private R&D investment

VI The main aspects of State aid to R&D policy that should be examined in the context of formulating a new R&D aid framework by the Commission

Rationale: The importance of R&D and public intervention

In the second half of the 20th century, governments have assumed a significant role in shaping the nature of technological change in their societies. The reason can be traced to two factors:

A. The first is the acknowledged contribution of technological change to the level of productivity, the rate of economic growth and therefore to living standards. The current consensus is that about one-third of measured economic growth in developed economies can be attributed to improvements in knowledge (Cameron, 1996). It was because of these that at the **Barcelona European Council** of 2002, which reviewed progress towards the Lisbon European Council (2000) goal[1], EU Heads of State and Government agreed that efforts should be made so that R&D investment in the EU is increased with the aim of approaching 3% of GDP by 2010, up from 1.9 % in 2000. They also called for an increase of the level of business funding, which should rise from its level of 56% to two-thirds of total R&D investment, a proportion already achieved in the US and in a few European countries.

An important point to make here is that, in order for governments to enhance the rate of economic growth and living standards, by intervening in the innovation generating process they could: (a) Take measures that **increase investment in R&D.** (b) Take measures that **improve the efficiency of R&D in generating innovations,** thus increasing the rate of introduction of innovations[2]. (c) Take measures that **enhance the efficiency of the process of innovation adoption and diffusion[3].** In this report we will be concerned mainly with measures under point (a).

[1] The goal of becoming "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" by 2010.

[2] Note that, increasing public spending on research will not necessarily have a significant impact on the rate of introduction of innovation if, for example, there is a lack of other complementary inputs, such as appropriately skilled human capital, an efficient technology-oriented education system and other institutions that facilitate clustering, provide venture capital etc, which are necessary for a high innovative capacity.

[3] This is the process by which productivity or quality improving innovations, **wherever they are first introduced**, get adopted and diffused in the economy, which is what ultimately creates the economy-wide improvements in social welfare and improvements in the rate of economic growth.

B. The second, complementary reason is based upon the notion that private markets are unable to generate an optimal quantity of R&D. It is well known that there are potentially significant **market failures** in R&D, or, more generally in the innovation generating process. Thinking of this as a multi-stage production process in which, at each stage, various inputs such as scientific personnel, other high-skilled labour, investment capital and the output of the previous stages are combined to produce a (stochastic) output, such as inventions and innovations triggering patents, new or higher quality products and lower cost production processes, the main market failures that characterize this process are the result of the factors described below:

(i) Appropriability problems that arise from the **public good nature of knowledge**. Specifically, the tendency to underinvestment in knowledge creation can be attributed to the more general phenomenon of **externalities** of which public goods can be seen as a special case. R&D provides many examples of positive externalities or spillovers – that is, unintended revelation of information about research results that "spill-over" allowing firms to free-ride on the research efforts of other firms. The knowledge generated by R&D can spill across other firms in the same industry, across industries and across countries. Evidence can be found in a wide range of empirical studies[4].

(ii) **Imperfections or market failures in the input and output markets.** Specifically, informational asymmetries make it difficult to finance R&D through private capital markets[5]. It is also worth stressing here the strong possibility that the prices of other R&D input goods may be distorted[6]. Market power in product markets will in many cases reduce incentives to invest in R&D[7].

(iii) Market failures associated with **sub-optimal coordination and information sharing** between firms. Even under perfect patent and IPR systems solving all the appropriability problems arising from free-riding by rival firms, and abstracting from capital or other input market imperfections, what can be shown is that, in the absence of any mechanisms or policies for promoting coordination and information-sharing between firms, there will be no socially optimal outcomes[8]. This is because:

---

[4] Social rates of return to R&D, that is, the annual rates of return experienced by industries, countries or regions resulting from investment by firms, are consistently higher than private rates of return, and often by a factor of two or more (Griliches, 1992; Nadiri, 1993; Fuglie et.al., 1996; Hall, 1996; Jonea and Williams, 1998). One study (Bayoumi, Coe and Helpman, 1998) found that a simulated increase in US R&D had a substantial positive impact on GDP growth rates in other developed economies, and in developing countries. This came about both because of the spread of knowledge from US R&D, and because the absorption of this knowledge stimulated investment in physical and human capital.

[5] As already noted the outputs of the R&D production process are stochastic and in many cases R&D activities are very uncertain as to their outcome. The firm undertaking an R&D project is likely to have significantly more information about the project than either competitors or lenders. A firm seeking a loan must divulge that information, but to do so runs the risk of releasing it to potential competitors. Thus firms tend to release less information than would be required to fully obtain needed capital. In addition, R&D projects tend to be riskier and to have longer pay-back periods than other investments and capital markets tend to undervalue risk and the future.

[6] For example, the wages of high-skilled workers depend on the level of general education provided by the government, the possibilities for advanced vocational training and/or the immigration laws as well as on other government policies that affect the demand for this labour. It is likely that the institutions deciding on these conditions either because they are not market driven or because they fail to coordinate in the presence of imperfect information will create conditions leading to under or over provision relative to the social optimum.

[7] For a summary of the literature around these issues see also the report on "The link between product market reform and macro-economic performance" (No. ECFIN-E/2002/002).

[8] The discussion here follows Katsoulacos and Ulph (1998a, 1998b and 2002).

a) There will be insufficient research outcome information-sharing between firms producing goods that are substitutes.
b) There may be an under-exploitation-of-complementarities in the research undertaken by different firms.
c) Alternatively, when firms' research programmes are duplicative, it will be socially optimal to operate a smaller number of labs and have these laboratories fully share the information. Thus we will have *excessive duplication* of R&D effort – an excessive number of R&D laboratories operate. Other things being equal this produces a consequent tendency for over-investment in R&D at the market level.
d) Even with perfect patents firms cannot appropriate the extra consumers' welfare from their innovations[9]. Thus they will under-value the returns to, and so will under-invest, in R&D. This is called the *under-valuation effect*.
e) Another reason for under-investing in R&D is that in deciding how much R&D to do firms take into account only the benefit of the R&D to themselves- they ignore the potential benefit that the outcome of their R&D could bring to others (if the results of their R&D were shared). This is *the stand-alone effect.*
f) A major reason for a firm's investment in R&D is to gain a *strategic advantage* by innovating ahead of one's rivals and so having a superior product or technology. This leads firms to over-invest in R&D since, from the point of view of society, it does not matter who innovates first. This over-investment is most dramatic in the case of what is known as tournament (patent race) models, but may also arise in non-tournament (or incremental innovation) models[10]. This is called the *strategic over- investment effect*.

(iv) Failures in the wider context concerning the **links between firms, universities and other economic agents** involved in the research and innovation process. Recent economic theories and empirical models (see Furman et.al. (2002), Porter (1990), Romer (1990)) looking at what determines an economy's **"innovation capacity"** – defined as the ability to not only produce new ideas, but also to commercialize a flow of innovative technologies over the longer term – conclude that the amount of R&D carried out (or the number of skilled researchers) and the appropriability conditions are necessary but not sufficient conditions for an effective innovation system. Broader framework conditions are important as well[11] and one of these that seems critical is the **interconnectedness of the agents participating in the research and innovation system.** Efficient networking between firms, universities, public research establishments and other elements of the innovation system is essential for its efficiency[12].

The role of Licensing and Research Joint Ventures (RJVs)
Licensing gives firms a direct financial reward for sharing information. The ability to license will potentially give firms incentives to share information when they are producing substitute products, and will reward them for sharing information that they would have been prepared to give away free when producing complementary

[9] Generally, price discrimination will allow firms to appropriate more of consumers' surplus or welfare (CS), but price discrimination will often not be feasible and only in the very unlikely case of perfect price discrimination can all CS be appropriated.
[10] Where firms choose R&D prior to making decisions on their output.
[11] The "competition conditions" to which we alluded in a previous section can also be regarded as one of these framework conditions.
[12] See Debackere, and Veugelers (2002).

products. However, it is well known that licensing will not resolve all information sharing problems, and also it is important to recognise that even when licensing induces firms to fully share information, it still has all the other R&D market failures. The promotion of **RJVs** has been one of the major policy instruments used by the Commission (via the Framework Programmes) for over 20 years, in its attempt to raise European R&D. RJVs can be thought of as a mechanism whereby firms are able to take decisions about **all** aspects of innovation – information-sharing; R&D; research design – in a collaborative fashion. Intuitively, by operating in a co-operative fashion an RJV can potentially address most of the market failures referred to above[13]. The only R&D market failure not addressed by RJVs is the *undervaluation effect.* This turns out to be crucial in appraising the performance of RJVs. Despite the potential of RJVs to solve most of the market failures they will not always perform better than a situation in which firms do not cooperate but can be involved in licensing. The fundamental reason is that, *all the other things equal*, RJVs will produce a greater undervaluation effect[14] than when firms do not cooperate[15] and this will tend to lead to greater underinvestment in R&D in the former case[16].

A question that emerges naturally following the above discussion is the role of **subsidies** in improving R&D performance. A quite large literature has emerged in recent years on the extent to which subsidies can replace RJVs as a means of solving R&D market failures (see Hinloopen, 1997a,b;2000) and Gravenitz and Ulph (2000b). Perhaps the main result to emerge is that, when research programmes are complementary, the use of R&D subsidies and the promotion of R&D cooperation are highly complementary policies and a government can achieve desirable outcomes with both policies that is cannot achieve with each alone[17].

2. Types of Public Intervention Measures

Intervention should aim to identify market failures and alleviate their effects, thus raising the production of innovations. Given the discussion above we can categorise forms of public intervention as follows:

1. Provision of public goods that are used as inputs in the production of innovations, such as education and basic research (government or university performed).
2. Alleviating market failures in input (financial and labour) markets and in output markets, by strengthening market competition. Specifically, to correct market failures in financial markets, governments can intervene through
    - Risk capital measures, or supporting venture capital markets
    - Guarantees for loan or equity financing
3. Regulatory measures that address appropriability problems generated by spillovers, such as an effective patent system. These measures must however be combined whenever possible with measures emphasizing the need to enhance information sharing and dissemination. This implies that:

[13] Given these potential benefits, it is not surprising that RJVs have received considerable attention - see the collection of articles edited by Poyagou-Theotoky (1997).
[14] See above (iii)(d).
[15] Coordinating their choice of R&D investment in a joint fashion (as a monopolist in the R&D market would) is what produces this effect: a monopolist's choice will always reduce consumer surplus and increase profit.
[16] See, for example, Katsoulacos and Ulph (2002). The emphasis in recent economic theory on the coordination and information sharing aspects of RJVs can also be found in the management and technology policy literature.
[17] Katsoulacos and Ulph (2002; page 286).

(i) A high degree of dissemination is allowed from basic research undertaken by the pubic sector that is used as an input by the private sector
(ii) A licensing system is established that effectively rewards information sharing between private firms and between private firms and public research organisations (including Universities[18]), and
(iii) Mechanisms that enhance coordination and information sharing and thus interconnectedness between firms and other actors of the research and innovation system are promoted. These include RJVs, and efficient networking and clustering between horizontally and vertically related research and innovation organisations.

The above three categories of measures, all of which affect expected R&D returns indirectly, can also be referred to as **Institutional Incentives** or measures that improve the **Framework Conditions**. In practice, in most countries, it has been always felt that these incentives are not sufficient or, more to the point, cannot be targeted in a sufficiently accurate manner and size, so in order to generate the optimal amount of private R&D additional measures are required that take the form of various types of **Financial Incentives**[19]**.** Thus we have:

4. **Financial incentives** to private R&D affecting directly firms' anticipated net returns from investing in R&D[20]. These may be:

- Direct government funding of business-performed R&D.

This includes **R&D procurement** (where results may belong to a recipient that is not necessarily the performer), and **R&D grants** or **subsidies** (where results belong to the performer). The latter includes various forms of grants, interest rate subsidies etc. These often include specific constraints aimed to simultaneously promote framework conditions e.g. firms may be required to establish RJVs.

- Indirect (fiscal) incentives. These include:

(a) **tax credits** – amounts deducted from tax liability
(b) **tax allowances** – amounts over current business expenses deducted from gross income to arrive at taxable income
(c) **tax deferrals** – reliefs in the form of a delay in the payment of a tax.

3. State aid Policy: General Comments and Potential Problems

State aid policy may be thought of as a subset of the public intervention measures mentioned above. In particular, they are usually associated with all measures under category 4 (financial incentives) as well as with some under category 2 (supporting venture capital markets and guarantees for loan or equity financing). More generally, State aid is one of a number of general instruments which a government may use to achieve certain objectives. The current approach stresses the objectives of rectifying market failures caused by externalities and other coordination and informational failures. There are various examples: as noted above a large number of such failures can affect investments in R&D and generally these will **not** be corrected by systems

[18] Such as the "Law on Technology License Organisations" of Japan (1998) – see also below.

[19] Note that the distinction between the various measures is not always completely clear cut. For example, the provision of a public good that reduces firms' costs in investing in R&D could also be categorised as a financial incentive. See also, for example, Besley and Seabright (1999).

[20] A major issue with respect to these financial incentives is the extent to which they are in a complementary relationship to private R&D investment. We review the empirical evidence that relates to this issue in Part V.

of (even effective) patents, licensing and the formation of RJVs[21]. However, some State aid is not solely based on an explicit market failure argument. Certain State aid policies, like regional aid, are based on objectives such as social cohesion or other **equity** or resource redistribution considerations[22]. It is often the case that both equity and efficiency considerations are simultaneously present in a State aid decision. For example, granting State aid to firms when they invest in research or production facilities in regions where there are previous declining industries. This might improve equity, but might also have an efficiency rationale.

Public support in the form of State aid is subject to control by the Commission. Indeed, a parallel policy development, in the framework of the Lisbon strategy, is that the Stockholm (2001) and the Barcelona European Councils called on Member States to continue to reduce public intervention in the form of State aid (measured as a percentage of GDP) while redirecting it towards more horizontal objectives of common interest (such as R&D), and target it to identified market failures. As noted by the Barcelona Council: “Less and better-targeted State aid is a key part of effective competition”. The rationale behind the general stance pointing to the need to reduce State aid levels can be found in three types of arguments:

First, in many cases public intervention fails to be guided by its stated objective. This can occur as the stated objective of a government - the maximization of social or consumers’ welfare – is in practice replaced by other objectives that are contrary to this – this is often termed **government failure -** objectives that can lead to inefficiencies. These other objectives are adopted because they nurture domestic constituency interests significant to the electoral cycle process.
Second, a number of government actions or government regulations, whilst they aim to correct market failures or satisfy other objectives, may themselves create other market failures by **distorting competition** and thus leading to inefficiencies that, apart from creating misallocation of resources, may also hinder innovation.

Thirdly, it is far from certain that government actions even when they are not subject to government failure and do not themselves create substantial market distortions will be successful in achieving the desired objective(s). When, for various reasons, they do not then public funds have been wasted. This is the important issue of the **effectiveness of public intervention** to which we devote Part V.

4. Brief Review of State aid to R&D Policy in the European Union

The Commission currently distinguishes between the following types of State aid:
1. Regional aid
2. Sectoral aid, specifically to the sectors of Coal and Steel[23], Transport, Shipbuilding, Agriculture and Fisheries

[21] Also, in the presence of Agglomeration Externalities, the profitability of a firm is greater if it is physically close to its horizontal competitors or to its suppliers and clusters of producers are therefore more efficient. By aiding the first firms to commence production, a government may make a cluster sustainable that would not otherwise be. In the presence of Environmental Externalities, production imposes pollution costs to society and State aid could be used to assist in undertaking “environmentally-friendly” investments.
[22] This of course implies that the effectiveness of this aid is not determined by market failure considerations.
[23] Council Regulation (EC) No 1407/2002 of 23 July 2002 lays down rules for the granting of State aid to the coal industry. In addition, the provisions of Article 88 EC Treaty and Council Regulation (EC) No 659/1999 also apply (State aid Scoreboard, Spring 2004, p.18).

3. Horizontal aid to: Research and Development, Environmental improvements, SMEs, Rescue and restructuring, Employment.

The main principles (96/C 45/06) concerning State aid to R&D policy are as follows:

(i) The closer R&D is to the market the more significant the distortive effect of State aid is considered to be. On this basis, aid to fundamental research is caught by Article 87 (1) only in exceptional cases while, as a general rule aid of up to 50% of gross investment can be allowed for industrial research and up to 25% for precompetitive development activities. When the research activity spans industrial research and precompetitive development the permissible aid intensity will normally be the weighted average of the intensities applicable to the two types of research.

(ii) The admissible intensity is higher where the recipient is a SME, where it is located in an area qualifying for regional aid (extra 10 %).

(iii) Gross intensities of 75% for industrial research and 50% for development activities (maximum intensities authorized by the WTO's Agreement on Subsidies and Countervailing Measures for non-actionable subsidies) may be authorized if similar projects of competitors located outside the EU have received (in the last 3 years), or are going to receive, aid of an equivalent intensity for the two types of research.

(iv) Innovation does not qualify as a separate category of R&D[24].

(v) Public financing of R&D activities by public non-profit making higher education or research establishments has normally not been covered by Article 87 (1). (Specific rules concerning collaboration with private firms apply).

(vi) Public authorities may commission R&D from firms or buy the results of R&D directly from them. If there is no open tender procedure the Commission assumes that State aid within the meaning of article 87(1) applies

(vii) R&D aid should serve as an incentive for firms to undertake "additional" R&D. Where this incentive effect is not evident, the Commission may consider such aid less favourably. To verify incentive effect particular account is taken of quantifiable factors (changes in R&D expenditure and personnel), market failures, additional costs connected with cross-border collaboration and other relevant factors indicated by the member state that made the notification. Proposed aid may also be permitted if it contributes towards expanding the scope of research or speeding it up.

(viii) The Commission recently amended block exemption regulation on SMEs in order to incorporate the new definition of an SME and to exempt aid for R&D to SMEs from prior notification to the Commission (364/25/2/2004, OJ L 63, 28/2/2004).

[24] Aid for activities that could be regarded as innovative but do not correspond to the above categories can benefit from state-aid only if it conforms to other Community State aid instruments.

Section B: Statistical descriptive analysis of trends in R&D categories and of the role of State aid to R&D in the overall public R&D support context

1. Statistical Analysis of the Data on GERD, BERD, HERD and GOVERD-Evolution over Time and Comparison between the MSs, USA and Japan.

1.1 Introduction

This Section consists of three Chapters. The first presents a comparative statistical analysis of all the main R&D expenditure categories–including HERD and GOVERD, categories that are particularly important for Part II below. Then, in Chapter 2 we provide a brief overview of the development of State aid over time in the EU. Finally in Chapter 3 there is a comparative overview of State aid policies towards R&D that includes:

i. Comparison between the Member States;

ii. Comparison of aid schemes using different aid forms (e.g. tax relieves vs. grants) at the level of a Member State.

Further, we provide a statistical survey of recent trends and descriptive analysis of:

- The ratio of public R&D support to industry which does not constitute aid (general measures such as general tax incentive schemes) to R&D aid.
- The importance of R&D aid compared to other aid granted for activities closely related to R&D (risk capital, intangible aid to SMEs etc).

The Data and Indicators for undertaking the statistical analysis below are contained in the Appendix to PART I[25]. The Tables referred to in the text below are in this Appendix and the analysis is based on these Tables, though a number of other sources have also been consulted and taken into account[26].

1.2 Trends in domestic R&D expenditure (GERD)

As it is clear from the data presented in Table A.1, US, EU-15[27] and Japan, the three main OECD regions, allocated in total 578.2 USD billion (current PPP) to R&D in 2002[28], accounting for more than 85% of all OECD countries[29]. R&D expenditure (in constant USD PPP) increased steadily in recent years. Table A.1 shows that in the 8 years following 1995, growth in the United States (6.3% per year on average) has slightly outpaced growth in the EU-15 countries (6.1%), as well as in the EU-25 countries (5.4%) and in Japan (2.8%). In 2002, R&D expenditure in the United States accounted for approximately 42.5% of the OECD total (USD 277.1 billion), close to

[25] General data on R&D (GERD, BERD, etc) and economic variables (GDP, value added) come to a very large extent from the OECD Science and Technology Indicators report (2004) and Eurostat (the data on Venture Capital). Data on State aid come to a very large extent from the State aid Scoreboard (spring 2004). The data are quite complete up to 2002. Scoreboard data for 2003 appeared in 2005 after the current report was completed.

[26] Specifically, the European Commission, DG Research Report “Towards a European Research Area – Science, Technology and Innovation: Key Figures 2003-4” and the OECD Factbook, 2003.

[27] Since, as already mentioned, our data are complete up to 2002, in many instances we will be referring to the situation in the 15 Member States, that is the situation prior to the recent accession of the 10 new Member States – though in many instances we will also be providing information and using the average for the EU -25 (including, that is, the new Member States) and for each of the new Member States.

[28] Although the tables provide data until 2003, we lack some data of this year for the majority of the countries. Consequently, 2003 will be referred as the last year only on cases where data are comparable.

[29] See also OECD, Science and Technology Statistical Compendium, 2004, page 9.

the combined total of the European Union (29.8%) and Japan (16.5%). Compared to average growth in the US over 1995-2002, R&D expenditure increased by 5.1% per year in Germany and by about 6% in UK and 3.6% in France. Only in the Slovak Republic did R&D expenditure decline during the second half of the 1990s. Overall it is the slower growth in the large EU countries (Germany, UK and France) relative to USA that explains the smaller growth rate in EU-15 and EU-25, given that smaller EU economies performed remarkably well during the period. For example, Finland achieved an excellent record of about 14% per year growth, Denmark 10.2 %, Sweden 9.5 %, Belgium 8.5 % - whilst some new Member States and catching-up countries also performed very well (e.g. Greece over 11% per year and Hungary 15%).

In the three main OECD regions, two trends in ***R&D spending relative to GDP*** can be distinguished after 1992 (Table A.2). In the period from 1992 to 1997 the ratio follows a downward trend in all three regions whilst from 1997 onwards (until 2002 that complete comparable data are presented) there is a steady upwards trend in the three regions. Considering the period from 1997, while in Japan the upward trend was due mainly to the stagnation in GDP since 1997 (see also Tables on GDP and Value Added Data in Appendix to Part I), in the USA, the rise was mainly due to significant increases in R&D, as GDP also grew rapidly. In the EU, in 2002, R&D intensity reached 1.95% for the first time in over a decade. Yet, as can be seen from Table A.2, the gap in 2002 was still over 0.7 percentage points below the US value and 1.17 percentage points behind Japan. Also, from Table A.2, in 2002, the highest R&D intensity within the EU was recorded for Finland (3.46%), while R&D intensity for Denmark and Germany (2.52%) was the second highest and clearly distanced from the rest of the EU economies, led by Belgium (2.24%), France (2.20%), and Austria (1.93%).

1.3 Character of R&D Activities

The character of the R&D performed - as basic research, applied research, and development – is shown in Tables A3 - A6. The division reflects the sectoral structure of each country's national system of R&D but also indicates differences in national priorities, traditions, and incentive structures.

Unfortunately, due to limitations of data availability, it is difficult to get a complete picture of the role of basic research in R&D systems (see Tables A.3 and A.4). Data after 1995 are available (and not always for all years) for only four (of the EU-15) Member States (Denmark, Spain, France and Portugal), four of the new Member States (Czech Republic, Hungary, Poland, and Slovakia), the US and Japan. In the period 1995–2002, expenditure on basic research in the US grew in real terms by almost 55% (Table A.4), while total R&D spending (GERD) increased by about 50% (Table A.1). Growth of expenditure on basic research was also clearly higher than that of total R&D in the Czech Republic but was clearly lower in Spain and Portugal.

As Table A.3 shows, expenditure on basic research as a percentage of GDP is much higher in the US, the Czech Republic and France (about 0.5%) than in other counties. In Spain, Slovakia, Portugal the figure is below 0.2% and in Hungary 0.24%. Using Tables A.4 and A.1 we note the quite large differences in the levels of expenditure on basic research relative to GERD. Thus, the share of 16.2% in the US (in 2002) entails the country's scientific leadership as well as the business sector's involvement in basic research. On the other hand, in many new Member States, high shares (e.g. in Czech Republic about 34%) are due to a business sector not yet involved in basic research and an R&D system still dominated by universities and government laboratories while in Japan, the low share (11,5%) reflects a long tendency of placing more emphasis on applied research and experimental development, though in the future more support is likely to be made available for basic research through the second Science and Technology Basic Plan covering the period 2002–2006[30].

1.4 GERD financing and performance

Tables A7-A12 show the share of R&D expenditure by main ***sources of financing*** i.e. business enterprises, government, other national sources and abroad, in each country for the years 1992-2002. It is obvious (see Table A.9) that the business sector plays the leading role in R&D financing in all the EU-15 Member States except for Portugal, Italy and Greece where the government seems to finance the greatest part of R&D. In 2001, Japan had the highest business share of financing (73%), followed by Sweden (72%), Finland (71%), and the US (67%). Belgium, Denmark, Ireland and Germany had shares of around 62-66%, while the shares for France and especially for UK were below the EU-15 average of 56% in 2001. In the new Member States, the business sector's share of R&D funding was in excess of 50% only in Slovakia, Slovenia and the Czech Republic, with the first reaching the EU-15 average.

Of course, the same countries that show the highest business sector shares of R&D investment, also record the lowest shares for government funding (Table A.7). The government share of R&D funding was clearly the highest in the EU-15 (34%), followed by the US (28%) and Japan (19%). Public funding accounted for less than 30% of the total in Sweden, Ireland, Belgium and Finland. At the other end of the scale, the EU economies of Portugal (61%), Italy (51%) and Greece (49%) and in most of the new Member States countries (but not CZ, SI, and SK) the R&D system was still mostly dependent on government contributions[31].

Regarding the level of the share of R&D funding from other national sources (Table A.11), it is clear that it is very low. Japan has the highest share (8%) followed by the US (5%) while EU-15 has even less (2%) with Finland having the highest (5.3) and Austria the lowest (0.3%).

In the EU-15, the share of funding from abroad (Table A.12) was almost 8% of the total. Among the EU Member States, this share was the highest in Greece, almost 25%. The share of foreign funding was also rather high, almost 20%, in Austria and the UK, and in Latvia was almost one-third of its total. The situation is the opposite in Germany and Finland, with funding from abroad being very low, at around 2%.

The business sector also ***performs*** most R&D (Table B.1). In 2001, the percentage of total domestic R&D expenditure (GERD) performed by the business sector was highest in Japan (73.7%), and the US (73%), with the EU-15 following (65%) - EU-25 (64%). However, growth rates for the period 1997-2001 of 3.1% for the EU-15 and

[30] See also DG Research Report "Towards a European Research Area – Science, Technology and Innovation: Key Figures 2003-4" EUR 20735, pages 24-26.
[31] Note that in a few cases the comparisons are not all for the same year – usually 2002 or 2001 – but for the latest year data are available for the country concerned.

2.7% for the EU-25, as compared to –1.9 % for the US and 2.3 % for Japan, point to possible convergence in the future.

There exists substantial diversity among EU Member States (Table B.1). Greece and Portugal (at just over 30%) remain quite far below the 50% level, while Italy (50.1%) and Spain (52.4%) find themselves only just above the 50% level. On the other hand, UK (67.4%), Ireland (68.5%), Germany (70.0%), Finland (71.1%) and Belgium (71.6%) are closer to the US, and Sweden (77.6%) is even higher than Japan. With the exception of Slovakia (67.3%), none of the new Member States have values higher than those for the EU-25, the EU-15, the US or Japan. And only the Czech Republic (60.2%), Slovakia (57.8%) and Slovenia (57.8%) exceed the 50% level. The other new Member States remain below that level to a smaller or a larger extent. The values for these countries could however rise in the future as significant restructuring is taking place there.

The higher education and government (intramural) sectors perform together on average about 35% of all R&D funded in the enlarged EU, while in US the share is about 22,5% and Japan 24% (Tables B.2 & B.3). It is worth noting that the higher education sector was the second largest R&D performer in most EU countries whilst the government performed a larger than EU average proportion (about 13%) of R&D in France, Netherlands, Greece, Spain, Portugal and in a number of the new MSs.

1.5 Business Expenditure on R&D (BERD)

BERD in the EU countries (Table C.1) has increased steadily over the past decade with the EU-15 average growing by 44% in the 1992 to 2001 period. Of the large countries only UK performed well (48% growth, while in Germany growth was 16,6% and in France and Italy even lower) but many of the smaller economies performed very well (Table C.1). However, comparing the *growth* of BERD as percentage of GDP (Table C.2), Japan presents the highest level of increase since 1995 which amounts to 20.2%, compared to 11.1% in the United States and 11.6% in the European Union.

Table C.3 shows that the Japanese business sector finances much more its R&D (97.8%) than either the US (90.6%) or the EU-15 (82.6%). In 1997-2001, business R&D financing grew somewhat faster in the US (1.3% per year on average) than in the EU-15 (0.25%), while the figure for Japan (-0.1%) took negative value.

From Table C.4, government financing accounts for a small and declining share of total industrial R&D in the EU-15, Japan and the USA. Government financing shares ranged from as little as 0.8 percent of industrial R&D performance in Japan to 12.3 percent in Italy – with 8% the EU-15 average (falling from 11,5% in 1992). In the USA in 2001, the Federal Government provided about 9.5% of BERD (the majority of that funding was obtained through DoD contracts).

Foreign sources of R&D funding increased in many countries between 1992 and 2001. The role of foreign funding in BERD varied from country to country, accounting for as little as 0.5 percent in Japan to as much as 23.7 percent in UK in 2001 (Table C.6). This foreign funding predominantly came from foreign corporations but also included funding from foreign governments and other foreign organizations. The growth of this funding primarily reflects the increasing globalization of industrial R&D activities. For European countries, however, the growth in foreign sources of R&D funds may also reflect the expansion of coordinated European Community efforts to foster cooperative shared-cost research through its European Framework Programmes.[32] Although the growth pattern of foreign funding has seldom been smooth, it accounted for more than 20 percent of industry's domestic performance only in the UK and Greece between 1995 and 2001. Such funding takes on even greater importance in many of the smaller countries as well as in less industrialized countries (OECD 1999)[33]. Although data exist on foreign sources of BERD funding for many countries, there are no data on foreign funding sources of U.S. BERD. However, the importance of international investment for U.S. R&D is highlighted by the fact that approximately 13 percent of funds spent on industrial R&D performance in 2000 were estimated to have come from majority-owned affiliates of foreign firms investing domestically.[34]

1.6 BERD performed in industrial sectors

Industrialised countries are experiencing deep structural changes towards the service sector. The share of the service sector amounts to around 50 - 70% of the total value added (GDP) and to 70 - 80% of total employment[35]. However, in contrast to the importance of the service sector in value added and employment, its efforts in R&D are rather low. Examining Table D.12 we see that the percentage of BERD performed in the services industries has been less than 15% in EU-15 in the nineties with the major economies, Germany and France, having an even lower percentage (of about 8% and 12% respectively), and UK being slightly above the average (18.5%). The same Table shows that Japan performs below EU-15 (with percentages less than 7%) while USA performs far above (with percentages reaching about 30% in the late 90s). Only two of the Member States allocate relatively more resources than the US to service sector BERD – Portugal with 49% and Denmark with 36%.

More specifically, perusal of Tables D.1 – D.12 indicates that on average in the US the 'Office & Computing Machinery', and 'Instruments' industries play a more important role in total BERD than in the EU, where 'Pharmaceutical' and 'Electronic' industries are more important with 'Aerospace' been of about equal importance. Within some EU countries the BERD is very much concentrated – such as in Finland, where electrical machinery (mainly the high-tech ICT industry) accounts for 58% of

[32] Since the mid-1980s, European Community (EC) funding of R&D has become increasingly concentrated in its multinational Framework Programmes for Research and Technological Development (RTD), which were intended to strengthen the scientific and technological bases of community industry and to encourage it to become more competitive. EC funds distributed to member countries' firms and universities have grown considerably. The EC budget for RTD activities has grown steadily from 3.7 billion European Currency Units (ECU) in the First FP(1984–87) to an estimated 15 billion ECU for the Fifth FP (1998–2002). The institutional recipients of these funds tend to report the source as "foreign" or "funds from abroad." Eurostat, *Statistics on Science and Technology in Europe: Data 1985–99* (Luxembourg: European Communities, 2001).

[33] OECD, 1999, R*&D in Industry: Expenditure and Researchers, Scientists and Engineers 1976–97,* Paris.

[34] The figures used here to approximate foreign involvement are derived from the estimated percentage of U.S. industrial performance undertaken by majority-owned (i.e., 50 percent or more) non-bank U.S. affiliates of foreign companies. The U.S. foreign R&D totals represent industry funding based on foreign ownership regardless of originating source, whereas the foreign totals for other countries represent flows of foreign funds from outside the country to any of its domestic performers. See Science and Engineering Indicators (2004) "R&D *Investments by Multinational Corporations*", National Science Foundation, Division of Science Resources Statistics, Arlington, VA (NSB 04-01).

[35] See for example Eurostat's REGIO database.

total BERD, and in Sweden (29%). In Denmark, the pharmaceutical industry produces and absorbs the bulk of industrial knowledge with a share of 23%.

1.7 Higher Education Expenditures on R&D (HERD)

Over the 1990s, ***R&D performed by the higher education sector (HERD) increased steadily*** (Table E.1) – by about 51% between 1992 and 2001 in EU-15. HERD's share of GDP in the EU in 2001 was 0.41% rising from 0.37% in 1992 (Table E.2 – for EU-25 the share was 0.39%), while in USA the share remained more or less constant close to 0.40% and in Japan there was a considerable fall from 0.53% to 0.44%. The higher education sector performed about 20% of total domestic R&D (GERD) in the EU-15 area in 2001 (Tables A.1 and E.1), compared to just over 14% in USA and Japan. ***The share of HERD in GERD has remained approximately constant in EU*** (about 20% in 1992) and Japan and declined in USA (about 18% in 1992).

There is much diversity within the EU with regard to R&D expenditure by the higher education sector (Table E.1). Whilst funding increased in all EU-15 countries, in some countries, funding share in GDP (Table E.2) has either stagnated (Germany, Belgium, Sweden) or even declined (Netherlands). Since the mid-1990s, countries such as Greece and Portugal have displayed the highest growth rates. Combining data in Tables E.1 and A.1 we see that the higher education sector plays an important role in the innovation system especially in Greece, Portugal, Italy, Austria, Spain, UK and the Netherlands where it accounts for over the EU-15 average of in 2001. Its share is below the EU average in Germany (about 16%) and close to it in France.

Because of the moderate role of Public Research Institutes in R&D, the higher education sector's share of total public R&D (HERD+GOVERD) in Belgium, Sweden and Austria exceeds 75%, when the EU average in 2001 was about 62% (in USA 65% and in Japan 60%)[36] – Tables E.1 and F.1[37]. The lowest percentages are recorded in France (53,5%), Germany (54,5%) and Italy (59%) in which PRIs play a more significant role.

Important is also the percentage of HERD financed by industry, as an indication of an overall pattern of increased university-firm interactions (often intending to promote the commercialization of university research). The proportion of HERD funded by industry for EU though climbing from 5.9% in 1992 it is still very small, at about 6.7%, in 2001 (Table E.3). In Belgium and Germany, more than 12% of university research was funded by industry in 2001. This is in sharp contrast to the very low percentage of France (at 3.1% one of the lowest). However, the situation is not the same in the new Member States where the role of industry as a financer of higher education expenditure on R&D seems to shrink. In USA and Japan the shares have remained more or less constant over the decade at about 6% and 2,5% respectively.

[36] In practical terms, this means that universities in Belgium, Sweden and Austria are expected to show an increasing commitment to the needs of the economy and society at large, and to collaborating with other R&D performers and users of research findings. Thus, universities are expected to assume a broader responsibility of what is called the "third mission".

[37] The calculations for USA and Japan rely on our data for GDP in the Appendix to Part I to obtain values of HERD and GOVERD.

1.8 R&D performed by the government sector (GOVERD)

The volume of intramural government expenditure on R&D (GOVERD) as a percentage of GDP in the EU, the US and Japan for the period 1991–2002 is shown in Table F.2. In 2002, governments in the EU spent a larger share of GDP on intramural research (0.25%) than the US (0.24%) but lower than Japan (0.3%). During the 1990's, the three OECD regions experienced different trends. While for the US the share was largely stable over the period 1992–2002 (dropping from 0,26% to 0,24%), for the EU it showed a slight downward trend (from 0.31% to 0.25%). It dropped in France, Italy and most significantly in the United Kingdom. The reductions are due to a decrease in defence spending and transfer from public agencies to the private sector. Japan is the only large OECD country where R&D performed by the government sector increased between 1992 and 2002, from 0.24% to 0.3% of GDP, as its laboratories benefited from science and technology policy initiatives over the decade.

- In 2001 the GOVERD share of GERD was about 11,6% in EU compared to about 9% in USA and 9,5% in Japan (Tables A.1 and F.1)[38]. ***In the preceding decade the share declined in the EU*** (from about 16,5% in 1992) – indicating difficulties for PRIs in re-defining their position following the changes in the legal and regulatory framework and the new societal and/or governmental demands of R&D, and increased co-operation between various actors throughout the R&D system – while it stayed roughly the same (small decline) in USA and increased slightly in Japan.

There is considerable variation in the share of the government sector in total R&D expenditure, within the EU area (Tables A.1 and F.1). At one end of the scale, Belgium, Sweden, Ireland and Austria spend very low proportions of total R&D (below 7%) in government laboratories. The government sector still plays an important role in R&D performance, in a number of countries: Netherlands (12.5%), Portugal (12.3%), Germany (13%), Greece (15.5%), Italy and France (15%).

Table F.3 shows the role of the business sector as a financier of R&D by public sector organisations. A growing share of funding by business enterprises would indicate their willingness to exploit public research, and that PRIs are willing to intensify co-operative activities with businesses and to commercialise their expertise. ***On average in the EU this is clearly not a prominent feature of the R&D system***[39]. The percentage has fluctuated in the decade prior to 2001 settling to 6,3% (from 5,6% in 1992 – but falling from a high 8% in 1999). However, it is certainly worth noticing the much higher share of public R&D financed by the business sector in Holland (22%), Finland (15%), UK (13%) and Ireland (10%). Disappointingly small is the percentage in Germany, 2,3%, falling from 3,4% in 1992.

1.9 Venture capital

European venture capital investment increased significantly during the second half of the 1990s, along with the development of the European venture capital industry (Tables G). However, in comparison with the US, the dynamics of the European venture capital industry lag behind dramatically, reflecting a far weaker force in the creation and expansion of new business activities (as can be seen by comparing its

[38] For US and Japan data from Table F.2 and the GDP data must be used to arrive at the percentages.
[39] Apparently, however, it is even less a prominent feature of the R&D system in USA and Japan.

share in GDP in EU and USA - see Tables G.2 and G.4). In the EU, investment has accelerated since 1998 but then breaks down abruptly.

"EU-15 venture capital financing of start-up, expansion and replacement (E&R) phases makes up only 54.8% of that in the US. Therefore, in spite of the drastic decline in US VC investment in 2001 and 2002 – EU-15 VC investment still lags behind dramatically"[40]. This means that substantially less start-ups have been founded and expanded by the European venture capital industry (other sources of finance might have been available in Europe). In 2001, however, the crisis of the new economy has broken the upward trend abruptly with venture capital investment declining by about 37% (E&R) and about 40% (early stage) in the EU (Tables G.3 and G.1). Clearly, in EU-25, venture capital investment will lag still further behind that of the US because in the new Member States the level of venture capital investment is still very low indeed.

The share of venture capital in GDP (Tables G.2 and G.4) – quantitatively very low, but with immense qualitative importance in the creation and growth of new economic activities – varies greatly from country to country, reflecting the relative importance of venture capital financing in the economy. There are considerable differences between the Member States as in Finland, Sweden and the Netherlands venture capital financing plays a fairly important role, while it plays a much smaller role in Austria, Portugal, Greece, Italy and France. However, it is important to realise that this indicator conceals very different institutional structures between MSs in the financing of new business ideas and the expansion of new firms.

2. State Aid Evolution – Comparison between the Member States.

2.1 Introduction

State aid policy in different countries is influenced by a combination of national and Community factors. The latter includes the requirements linked to economic policy co-ordination, the budgetary criteria of the Stability and Growth Pact, and the co-financing priorities within the Community regional policy. The former relates to national specificities which may change over time. Some MSs might have to concentrate aid on regional policy objectives for reasons of economic and social cohesion, whilst others, during a certain period of time, have to face massive restructuring in particular sectors. Some MSs might not need to grant as much State aid as others to support SMEs if their regulatory environment and capital markets already facilitate conditions for their development.

2.2 Overview of State aid in the European Union

State aid in Europe, though declining in value since the early 1990's still constitutes one of the EU's major commitments being of about the same order of magnitude as EU's commitment for agriculture spending and EU's structural funds. Total State aid in 2002 was 49 billion Euro (0,56% of EU15 GDP) (Table H.1 and H.5), ***falling*** from 67 billion in 1997 and 52 billion in 1999. Of the 49 billion around 28 went to manufacturing and services, 14 to agriculture and fisheries, 5 to coal and 1 for

[40] DG Research Report "Towards a European Research Area – Science, Technology and Innovation: Key Figures 2003-4" EUR 20735, page 39.

transport (excl. railways). Large disparities of aid between member states still exist. The share of aid to GDP is around average in Germany, Spain and Portugal (0,55%), above the average in Denmark (0,72%), and below the average in UK, Sweden, Finland and Netherlands. Tables H.4.1 – H.4.15 give detailed State aid data for each of the EU-15countries (for the period 1992 - 2002).

Table H.1 shows a gradual shift in the share of aid away from specific manufacturing, coal and service sectors towards horizontal aid. Moreover the sharp drop in 1999 of the share of aid destined to specific sectors was matched by a significant increase in the shares of aid granted for horizontal objectives. As is noted in the CEU State aid scoreboard (2001), "State aid for horizontal objectives, i.e. aid that is not targeted towards specific sectors or geographic areas, is usually considered as being less distortive than sectorial and ad hoc aid, such as aid for rescue and restructuring. The possibility to grant aid horizontally to all sectors implies that it has a less selective effect and its positive effect in addressing market failures is more likely to outweigh its negative impact on competition".

In the EU[41], the largest portion of aid (excluding aid to agriculture) has been aid for the assisted Article 81(3)(a) regions. Although aid in regions has declined considerably from €19 billion in 1992 to €7.7 billion after a decade, regional objectives are still the single most important target for support. This is particularly true for Greece, Portugal and Italy. Among horizontal, Research and Development (R&D) aid has increased from €3.6 billion in 1992 to €5.2 billion in 2002, an increase of 44.4%. This trend has been particularly the case of Austria, Germany, the Netherlands and Sweden. Support to SMEs increased from €4.1 billion in 1992 to €4.9 billion after a decade. SMEs support is particularly significant in Luxembourg, Belgium, Finland, Austria and Italy. With regard to other objectives, environmental protection and energy savings saw a substantial increase of 279% amounting to €5.3 billion in 2002.

2.3 Towards a reorientation of State aid

Table I.2, indicates that in 2002 aid earmarked for horizontal objectives, including cohesion objectives, accounted for 73% of total EU aid less agriculture, fisheries and transport. It is obvious, that ***since 1992 there has been a steady upward trend in the amounts of total aid granted to horizontal objectives in the EU*** - this share has increased by 15 percentage points in the decade 1992-2002.

In line with the commitments undertaken at the Lisbon and Stockholm European Councils, Member States have been redirecting aid towards horizontal objectives. Looking at recent trends, the share of EU aid granted for horizontal objectives increased by 6 percentage points in 2002 since 2000. This was largely the result of a sharp increase (about 23%, Table H.1) in aid for Research and Development.

It has to be noted that the positive trend during the last few years, was observed, to varying degrees, in the majority of Member States. Most Member States directed, in 2002, between 70% and 100% of their aid to horizontal objectives with the exemption of Germany, Spain, France, Ireland and Portugal whose share was significantly lower

[41] The Figures mentioned in this paragraph come from Table H.1 and Tables H.4 in the Appendix to Part I.

(Table I.2). However, in Spain and Portugal the share of horizontal objectives increased by 9 and 19 percentage points in the last two years respectively. In Ireland the share rose by 14 percentage points while in Germany, France and the Netherlands by about 3-4 percentage points

Concerning comparisons as to objectives of horizontal aid, it is important to bear in mind that aid schemes are classified according to their primary objective. As a result, the level of horizontal aid for some objectives may well be underestimated as they are classified elsewhere. For example, some aid classified under 'SMEs' may also be aimed at 'R&D'. Notwithstanding the measurement difficulties[42], the data do give an indication as to which horizontal objectives are favoured by each MS. For example, in 2002, Table I.3 indicates (in conjunction with Table I.1) that around 45.5% of aid to horizontal objectives in Finland, 38% in the UK, 34% in Austria and 30% in France, was directed to R&D (EU average of 20.9%), while Denmark (45%), Germany (43%) and Sweden (39%) tended to favour environmental objectives, while in Portugal 39% of aid granted to horizontal objectives was earmarked to SMEs[43].

3. State Aid to Research and Development – Evolution and Comparison

3.1 The evolution of R&D aid and its share in GDP

Table J.1 presents the evolution of R&D aid in the EU. The Table shows that R&D aid in the European Union has followed an upward trend in the decade 1992-2002. As one can observe from the table, R&D aid in the EU, in 1992, was about 3.5 billions Euros and in 2002 amounted to about 5.2 billion having increased by 48.6%, an average of about 4,5% per year, though it is worth noting that the increase is quite substantial from 2000 onwards – about 11% per year. Also, the majority of the MSs follow this increasing direction. Remarkable is the fact that in the UK and in Germany, the amount of R&D aid granted since 1992 has experienced an increase of over 100%, reaching, in 2002, 0.7 billion and 1.58 billion, respectively. On the other hand in France and Italy aid remained more or less constant. The only MSs that report a decrease in their amounts of R&D aid are Denmark, Sweden and Luxemburg.

Table J.2, which presents the historical evolution of the share of R&D aid to GDP, indicates that EU in the decade 1992-2002 allocated only 0.06 of 1% of the GDP as State Aid to Research and Development activities. This share has increased very slightly (by about 7,2%) since 1992. We observe from the table that Finland has the highest share of R&D aid to GDP (0.14 of 1%) in 2002 (it also had the higher R&D expenditure as percentage of GDP at 3.42%), followed by France, Germany, and Austria, whereas Luxembourg, Portugal and Sweden allocated only about 0.025 of 1% of their GDP to R&D aid. However we must note that figures show that R&D aid as a percentage of GDP, changed very little in all 15 Member States between 1997 and 2002. Only UK and Ireland recorded a threefold increase during that period.

3.2 R&D State aid instruments – Comparison between Member States

Grants are by far the most frequently used form of aid instrument making up 70,5% of the EU total in 2002 amounting to 3,7 billions. This holds true for all the period

[42] Point made in State aid Scoreboards – see in particular June 2004 update, page 20.
[43] Figures also given in State aid Scoreboard, Spring 2005 update.

1992-2002. From the Table J.3[44] it appears that R&D aid granted in the form of grants in the EU has experienced an increase of 42,5% since 1992. In addition to aid awarded through the budget, other aid is paid indirectly through the tax system. So, as indicated, tax exemptions make up 8,5% of the total in 2002 (0,4 billions), while in 1992 tax exemptions represented 18% (0.65 billions) (Table J.10 and J.11). It is worth noting that, while in 2002, Greece, Germany, Denmark, Luxembourg and Finland provide more than 90% of their aid in the form of grants, the United Kingdom makes far greater use of tax exemptions (51%).

Concerning ***other forms of aid instrument***, in the form of a soft loan or tax deferral[45], EU-wide, soft loans represent 20% of all R&D aid in 2002, while in 1992 were representing only 7,2% (Table J.3). In the last few years, in France (59%), Spain (38%), Belgium (29%) and the UK (21%) the proportion is higher (Table J.3). A similar instrument - tax deferrals - is almost negligible as a form of aid instrument in the EU (Table J.3). As far as aid in the form of state equity participation, this represents less than 1% of all EU aid to R&D for 1992-2002 (about 0,7 of 1% in 2002), amounting to only 36 millions (in 2002 - Table J.3). Finally, aid may be provided in the form of guarantees, expressed in nominal amounts guaranteed[46]. The share of guarantees in overall levels of EU aid to R&D amounts to well under 1% (Table J.3).

The data on Table J.8 indicate the ***minor importance of tax exemptions and tax deferrals*** in comparison with all the other aid instruments. So the EU ratio of Grants, Equity Participation, Soft Loans and Guarantees to Total R&D Aid follows an upward direction since 1992. More specifically in 1992 the ratio was 81% while in 2002 it had increased to 93%. Denmark, Ireland, Luxembourg, Portugal and Finland characteristically do not use fiscal incentives at all. The only exemption in this situation is the UK where this ratio was 49%, indicating that 51% of the aid was given through tax exemptions and tax deferrals. One can however notice that for the UK the latter ratio fell dramatically since 2000 experiencing a decrease of almost 50%. However, it is not surprising to find that tax exemption instruments are of minor importance given that the data presented here do not include ***general tax measures***, such as nation-wide tax breaks, that are used in many countries to raise private R&D.

3.3 The Importance of R&D aid relative to the various R&D Expenditure Categories

In 2001, in the EU, State aid to R&D accounted for only 4.4% of the business expenditure on R&D (BERD, Table J.4). In 1992 the same ratio amounted to 4,7% and up to 1999 the ratio of total R&D aid to BERD experienced some small fluctuations. However, since 1999, this share seems to follow a rather upward direction having increased by about 15 percent. We should mention here that the

---

[44] Here we concentrate on R&D aid. For the use of different instruments in State aid generally see Tables H.2 and H.3 in Appendix to Part I.

[45] The aid element is the interest saved by the recipient during the period for which the capital transferred is at his disposal. See also State aid scoreboard Spring 2002, http://europa.eu.int/eurlex /en/com/rpt/2002/ com2002_0242en01.pdf

[46] "The aid elements are normally much lower than the nominal amounts, since they correspond to the benefit which the recipient receives free of charge or at lower than market rate if a premium is paid to cover the risk. However, if losses are incurred under the guarantee scheme, the total loss, net of any premiums paid, is included since it can be considered as a definitive transfer to the recipient" - State aid scoreboard Spring 2002, http://europa.eu.int/eurlex /en/com/rpt/2002/ com2002_0242en01.pdf

average EU ratio of the total R&D aid to Industry Financed GERD accounts to 5.25% (and to BERD accounts to 4.9%) in the period 1992-2001. It is worth thinking about what this means in terms of the Barcelona objective. ***Doubling the level of R&D aid from its 2002 level (of about 5,2 billion Euro) would close that year's gap in Industry Financed GERD (and BERD) between EU and USA by just about 6,5%.*** Alternatively, we may notice that in the 7 year period from 2003 to 2010 the growth in the aid to R&D in the EU would have to grow by about 45% per year (rather than 4,5% that it grew on average in the decade before) in order to close the gap in Industry Financed GERD (or BERD) between the EU and USA.

The Table also shows that in many EU countries the ratio of R&D aid to BERD remains stable with very small variations. As a matter of fact, many of the Member States are above the EU average. More specifically, Italy and Spain present a very high ratio in comparison with other countries, and their total R&D aid account to 10.6% and 10.4% of their BERD, respectively. On the other hand, Sweden and the UK report a very low ratio, far below the EU average, which amounts to 0.82 of 1% and 2% respectively.

As far as the ratio of total R&D aid to Government Financed BERD is concerned (Table J.5) EU presents a steady upward trend during the decade 1992-2001 with its share to increase by about 15% each year and total R&D aid reaching, in 2001, the highest point of 55% of the Government Financed BERD, while in 1992 it was 41%. Here, we should point to the fact that Finland, Portugal and Spain present the highest ratio of the total R&D aid to Government Financed BERD, over 100% in each case, far above the EU average. The lowest ratio is found in the UK (17%).

The ratio of total R&D aid to the Government and to the Industry Financed GERD is presented in Tables J.6 and J.7, respectively. In both cases EU reports a slowly increasing trend in the 2-3 years prior to 2001. More specifically, data on the ratio of the total R&D aid to the Government Financed GERD in the EU indicate that this ratio has increased since 1992 by 12 percentage points, with total R&D aid reaching in 2001, 8.4 % of the Government Financed GERD. It is worth noting that this ratio has increased by 19.5% since 1999, when it amounted to 7%. We should also note that Finland (16%), Austria (13%), Spain (13%), Belgium (13%) and Germany (10%), report the highest ratios, far above the EU average. This fact holds true for all the period 1992-2001. As far as the ratio of total R&D aid to Industry Financed GERD is concerned, the situation changes only slightly. So here, as already mentioned, EU reports historically a steady ratio of around 5.25% for the decade 1992-2001. We note that Austria and Spain have the highest ratios which amount to 14% and 12% respectively. On the other hand, Germany and Belgium fail to even reach the EU average R&D aid as a percentage of Industry Financed GERD (5% and 4.4% respectively).

When comparing R&D aid with public expenditure on R&D (HERD+GOVERD, Table J.9), we notice that the situation is almost the same – in particular, in percentage terms, the magnitude of ***spending on R&D aid is very small relative to total government spending and has increased by only about 3,5% between 1992 and 2001***. So, total EU R&D aid in 1992 is shown to be about 8% of the public expenditure on R&D and in 2001 the same ratio amounts to 8,4%. Data show that until 1999 there are some small fluctuations but from that year an upward trend seems to emerge. It should be noted that Belgium, Germany, Greece and Finland are far above the EU average, while Sweden and UK are fairly below this average.

3.4 The importance of R&D aid compared to other aid granted for activities closely related to R&D (i.e. risk capital, intangible aid to SMEs)

Small and medium-sized enterprises (SMEs) make a major contribution to the European economy in terms of growth and job creation but also in terms of the development of new products and services. Table K.1 presents the historical evolution of aid to SMEs. Intangible aid to SMEs in the EU was 4.1 billions in 1992 and 4.8 billions in 2002 having on average increased by about 17%. There are significant variations during the decade 1992-2002. However, since 1998 there is a ***decrease*** of about 22%. We should note that in the majority of the countries the amount of intangible aid to SMEs follows an increasing direction since 1992. Only in Germany, Greece, Ireland, Italy and Netherlands this seems not to be the case.

From Table K.2, it appears that the share of aid to SMEs to total R&D aid varies considerably among the different Member States and to a lesser extent, over time. We observe that in 1992 for the EU this intangible aid to SMEs was about 116% of the Total R&D aid, been 25% higher in comparison with 2002, where the ratio has fallen to about 94%. It is obvious from the table that since 1998 that ratio decreases with an average rate of 18% every year. At this point, it is worth mentioning that Portugal, Italy and Luxemburg reported in 2002 the highest ratio of intangible aid to SMEs to total R&D, with their shares amounting to 325%, 250% and 236% correspondingly. These three countries experienced the greatest fluctuations in the period 1992-2002 and we should also note that during the above period their share of Intangible aid to SMEs to Total R&D aid was always above the corresponding EU average.

This situation does not change when we examine the share of Venture Capital (VC) Investments (expansion & replacement and early stage) to Total R&D aid (Tables K.3 and K.4 respectively[47]). As it is known, the VC industry plays a strategic role in financing high-risk, potentially highly rewarding business projects, and providing management skills. The VC industry finances all types of necessary – intangible and tangible – investments – related to the setting up and starting of a new business venture, to the expansion of a start-up and to the restructuring of existing businesses. Data indicate that the share of VC investments both for expansion & replacement and early stage to Total R&D aid increased significantly since 1995 and until the New Economy crisis (at about 2000). More specifically VC Investments for expansion & replacement to Total R&D aid were 136% in 2001 having increased by about 85% since 1995. Sweden, UK and Netherlands have the highest ratio in 2002, 565%, 341% and 304% respectively, which far exceeds the EU average of 136%. On the other side, Greece (1.9%) and Austria (64%) have ratios significantly below the EU average.

As far as the ratio of early stage VC Investments to Total R&D aid is concerned, this was 48% in the EU in 2002 having experienced a five-fold increase since 1995 – but a reduction to a third of its 2000 level. Sweden and Denmark report the highest ratios, 330% and 206% respectively. Greece, again, reports the lowest ratio, 0.7%. Tables K.3 and K.4 make clear that despite the continuously increasing amounts of VC

[47] Tables K.3 and K.4 use information from Tables G.1 and G.3 on VC investments (these are divided by R&D aid). The information on VC investment in G.1 and G.3 comes from Eurostat.

investment during the years after 1995, State aid has gained greater relative importance in the EU and in many MSs in the years after 2000. This is particular true for early stage venture capital.

3.5 Overall Conclusions

1. Since 2000, as a result also of the compliance of MSs with the Commission's recommendation concerning the redirection of state support towards horizontal objectives (such as R&D), R&D aid has increased significantly in importance as an aid category. It is now much more important relative to VC investment and other forms of state aid having increased from €3.6 billion in 1992 to €5.2 billion in 2002, an increase of 44.4%, or from a share in total horizontal aid of 11,5% to 21%.
2. The most important instrument for providing aid to R&D is grants, its significance having increased over time (since 1992). The only MS, UK, which was adopting tax exemptions on an equal basis, has now reduced its reliance on this instrument too.
3. What emerges from the statistical analysis above is that State aid to R&D still does not represent a significant factor in the overall R&D activity of the EU. This is true whether its significance is judged in terms of its size relative to the various R&D expenditure categories – State aid to R&D accounted for only 4.4% of business expenditure on R&D in 2001, just over 5% of industry financed GERD, 7.5 % of the Government Financed GERD and 8,4% of (HERD+GOVERD). It is also true when judged in terms of the relevance of State aid to R&D for closing the gap in business expenditure on R&D with EU's major competitors. A huge increase in its (2002) magnitude, requiring a much greater percentage increase per year than that achieved on average between 1992 and 2002 (4,5%), or even than that from 2000 to 2002 (11%), is necessary in order for State aid to R&D to make a significant contribution towards achieving the Barcelona objective (it should grow on average by 45% per year between 2003 and 2010 for the BERD gap between EU and USA to close). Of course, this ignores that State aid may well have a leverage effect on private R&D (indeed we show that it does in Part V below) and that, for given R&D aid, an improvement in Framework Conditions in the EU could also assist considerably in closing the gap, though the impact of improving these conditions on business expenditure on R&D is likely to be much more long-term. Also, it is worth stressing here the potentially important role of ***general measures*** (not classified as State aid[48]) towards closing the gap in business expenditure on R&D with EU's major competitors.

[48] In this respect see also point in relation to tax policy in Chapter 3.2 above.

PART II

Description and analysis of the role and recent functional changes of Public Research Establishments (PREs) and of their links to industry

1. Introduction: Rationale and Main Objectives

The role of Public Research Establishments (PREs) - such as Universities and other Public Research Organisations/Institutes (PROs/PRIs)[49] – in a country's research and innovation system is a huge subject with a very large number of theoretical, empirical and policy dimensions. In this report our objective is to examine some of these dimensions - in particular, for PREs mainly in the EU countries, USA and Japan, to examine the following:

i. Examine recent trends in the R&D expenditure of the public research sector, i.e. Higher Education and PRIs (this was dealt with in Part I.B above).
ii. Examine important changes in IPR rules in relation to PREs and of "institutional" changes during recent years, i.e. changes in the legal form of PREs, with emphasis in the European area.
iii. Examine trends in the commercialisation activities of PREs, i.e. patents, licenses, licensing income, spin-offs generated, contract research etc. Also, examine obstacles which may be hindering commercialisation activities and closer co-operation with industry.
iv. Examine policies towards and trends in co-operative agreements and partnerships between PREs and industry (this is essentially examined in Appendix 3 to this Part – see also Chapter 4 below).

The importance of PREs and their evolving role in the research system

PREs have always been the major creators of fundamental scientific knowledge through Basic Research. Though private firms now perform some Basic Research,[50] the generic nature of the scientific knowledge produced and thus its public good character as well as the huge risks (pure uncertainty) involved in its production, suggest that PREs will continue to be the main players in this area. Given the key importance of basic research as an input to the applied research and development undertaken by private firms, that is necessary before introducing new products and processes to the marketplace, the belief has been growing for some time that universities have to expand their role and become more involved in the transfer of knowledge to economic actors in the private sector[51]. More specifically, the argument has been that universities have to ensure that the input they provide is transferred in an efficient manner and is useful to firms – which imply that universities must make their research more directly in line with industrial needs. Further, according to this argument, incentivising Universities to do so by allowing them to get IPRs on their inventions will allow them to relax the severe budget constraints they are facing since the late 1970s. However, the danger is that, doing this may reduce the amount of fundamental research undertaken with negative (not readily foreseen) long term implications for the research system. Thus, as pointed out by Beath, Katsoulacos and

[49] Throughout this Part we will generally using "PRE" to indicate both Universities and other public research organisations and "PRI" to indicate non-university research institutes.

[50] The reasons are that they may feel it is necessary to fill gaps in the universities' research portfolios. Or, they may do it to get patents and earn financial rewards from these (e.g. genome research). Finally, they may do it to ensure that they have the necessary understanding to effectively absorb the results of university research.

[51] The existence of geographically mediated spillovers from university research to commercial innovation has been explored in a series of econometric studies following the initial work of Jaffe (1989), while the policy importance is apparent in two relatively early key policy documents (published during 1998). The first of these was the World Bank's *1998 World Development Report* and the second was the UK Government's White Paper *Our Competitive Future: Building the Knowledge Driven Economy.* See also Navaretti, Dasgupta, Maler and Siniscalco (1998), for a survey of recent academic work in this area.

Ulph (1999), the trick that the policy has to pull off is the very difficult one of achieving maximal information sharing amongst scientists, which will allow maximal fundamental knowledge output in the long run, while simultaneously protecting intellectual property between scientists and industry.

Notwithstanding the potential dangers, the traditional role of PREs and the framework of interaction between them and the private sector and governments have undergone significant changes in many countries over the past two decades. As far as governments are concerned, supporting various forms of collaboration between universities and the private sector has been seen as one way to achieve the objective to improve the efficiency of the innovative base of the economy. Further, collaboration could enhance the training of graduates and facilitate personnel mobility between universities and the private sector. Finally, governments expect that a closer collaboration between universities and the private sector will allow universities to compensate for reduced government funding.

In turn, university attitudes towards industry-sponsored research have been changing, owing to cutbacks in government funding and to new opportunities to benefit from commercial relationships, including patent licensing and fees from technology transfer. The establishment of technology transfer offices/institutes or industry liaison offices at many universities and the explicit inclusion of technology transfer obligations into university mission statements are some of the indicators of changing attitudes. Similarly, universities no longer see public funds as the only appropriate source of financing for university activities – even though it still remains the main source. Such attitudes are encouraged and stimulated by the trend of governments to refocus their criteria for R&D funding towards performance and economic impacts.

On the industry side, there is growing appreciation for the quality of research conducted by universities and PRIs. This is partly due to the emergence and expansion of science-based (high-technology) industries such as biotechnology and microelectronics, where firms need access to the skills and research input of universities. Faced with their own declining profit margins, many firms are also outsourcing a greater share of their research[52].

2. Changes in the Institutional, Legal and Regulatory Environment of PREs

There have been substantial changes in the institutional, legal and regulatory environment of PREs in recent years. Starting with PRIs the changes have involved the creation, restructuring, reorganisation or renovation of industrial research centres. As noted in a recent PREST report (2002), laboratories outside the Higher Education sector usually have a mission beyond the performance of basic research. While some such institutions were founded early in the 20th Century or even before[53], there was a massive expansion in the second half of that century. Table 1 below provides some

[52] A recent study (Conference Board of Canada, 1998) on the trend to outsource R&D found that corporations take into account: i) internal drivers, which reflect corporate acceptance that they are not large or wealthy enough to know and develop everything and yet need to manage in an increasingly complex environment where innovation is the key to corporate survival; and ii) external drivers, which are based on the increased opportunity to obtain knowledge available outside the corporation, particularly through partnerships with universities and PRIs.

[53] The oldest laboratory in the database is the Royal Botanic Garden Edinburgh founded in 1670. Other centres originating pre-20th Century are usually observatories, geological surveys and meteorological labs, with health and agriculture becoming more common towards the end of the century.

examples of recent changes in policies affecting the structure and operation of PRIs in Europe, indicating the changing environment in which they operate.

Table 1: Examples of Recent Changes in the Structure and Operation of PRIs in Europe

Country	*Date/Title*	*Comments*
Denmark	2002, Danish Growth Strategy	Each Government research institute to be governed by an independent board of directors. Funds for public research made available above the basic grant are to be offered on a competitive basis between the public research institutions.
Greece	2001, Law 2919/2001; Presidential Decree 17/2001	The law seeks to promote better linkages between research and production. There also has been a reorganisation and concentration of independent research centres. Incentives for greater exploitation of new knowledge and research results provided together with development of high-technology incubator and technology parks and support for public research and university spin-off companies. The general Secretariat for Research and Technology (GRST) in addition to managing the above, also operates the Operational Competitiveness Programme (2002-6) which seeks to upgrade public research centres, develop centres of excellence and make them more competitive.
France	1999, Innovation and Research Law (Law no. 99 -587)	One of the objectives of this Law is to increase collaboration between PRIs and private companies and to increase and improve the dissemination of research results
Ireland	2003, National Code of Practice	The Irish Council for Science, Technology and Innovation recommended the introduction of a National Code of Practice for the management of Intellectual Property. Promoted by recognition that there was an absence of systems in place in Ireland to support the identification and exploitation of IP from publicly funded research. This new measure is aimed at public research institutes, universities and institutes of technology.
Italy	2003, Acts 127/2003, 128,2003, 257/2003 Review of Public Research Institutes	Reform and reorganisation of CNR, (the largest PRI), the National Institute of Astronomy and Astrophysics and the Italian Space Agency to facilitate greater participation in major international research networks. The reforms are characterised by a more managerial approach allowing scientists to formulate projects.
Netherlands	2004, Evaluation Committee	The recently conducted evaluation of the PRIs for applied research will lead to a fundamental change from institutional to demand oriented programme funding.
Slovenia	2001 onwards	Ongoing changes to the running of PROs under the following: The Strategy for the Economic Development of Slovenia (2001); The National Development Plan 2001-2006 (2001); Research and Development Activities Act (2002); Single Programming Document 2004-2006 (2003); National R&D Programme 2004-2008.
Spain	2002, Normative Amendment to the	The amendment to the Science Law broadens the

	Science Law	scope for PROs to participate in or create firms. Previous restrictions meant that public research organisations could only take part in firms related to technical services or with research aims. Now the company's aims may include the transfer and exploitation of patents, innovations, scientific knowledge and industrial property rights.
Sweden	2001-2, R&D and Cooperation in the Innovation System	Reorganisation of the structure of public funding for RTD. This bill focuses on the role of the semi-public industrial research institutes and the Swedish Agency for Innovation Systems (VINNOVA). The research institutes were to be restructured to create a flexible and efficient structure with a few internationally competitive institutes that have strong industrial support.
UK	1998, Strategic Defence Review, MoD	Division of Defence Research Establishment into two organisations the Defence Science and Technology Laboratory and Qinetiq, a public private partnership. In 2003 the UK introduced a new initiative Defence Technology Centres to encourage collaboration across sectors to generate, develop and exploit innovative technology for UK Defence. The UK has a Continuing programme of privatisation of government research establishments and active support for commercialisation of IP in public sector research institutions.

Source: CREST Report (2004)

A common factor behind the policies mentioned in the Table above has been the recognition that PRIs should get more involved in commercialisation activities. The most radical changes are expected to emerge in privatised PRIs. However, changes in ownership have not necessarily signified the complete withdrawal of government. Privatisation has usually been accompanied by continuation of government sponsorship on a contractual basis. A recent volume[54] identified a series of challenges facing the sector – the main ones been:
. A changing relationship with other actors in the innovation system;
. Renewal of infrastructure and human resources;
. The challenges of research commercialisation;
. Development of adequate procedures for the measurement and evaluation of the processes and effects of research;
The EUROLABS research project[55] provides a more detailed account of the evolution of research centres during the last decade in the European area[56]. According to this, "the two dominant ownership categories are central government and non-profit foundations. Smaller numbers of laboratories have passed from government into the private sector, or are owned by regional government or universities. There is a wide

[54] Cox D, Gummett P and Barker K, (2001).
[55] PREST, (2002).
[56] The main objectives have been to conduct a comparative analysis of public, semi-public and recently privatised research centres, and to compile a database to describe the main features of major research centres. Currently, 769 centres are included in the database. The centres in the database employ over 100,000 qualified scientists in the 557 centres for which data are available. While the greatest number of centres (237) employ between 10 and 49 scientists, the greatest number of scientists work either in large organisations (45,241 in 18 organisations) or in centres with 100–499 scientists (33,785 in 151 centres).

variety of ownership profiles across EU countries. In Germany, Spain, Sweden, the Netherlands and Portugal, ownership by central government is relatively infrequent (less than 25% of entries). At the other extreme, this is the only model in Greece, while Italy, Ireland and Finland all have more than 80% in this category. Non-profit foundations are the dominant models in Germany, Portugal and France. Regional ownership is significant only in Belgium, the UK (mainly Scotland), and Spain. Eight countries have some private sector presence but ***only five (Austria, the Netherlands, Italy, Sweden and the UK) report as privatisation the change of status described, covering 32 laboratories in all (out of 705), in the period 1989–2001[57]"***.

As the report further mentions "Ownership may also be mixed or "semi-public". The emergence of this model can be seen in the case of industrial research institutes in Sweden. Originally established for specific industry sectors, but now organised around technological competence, they receive around one third of their income from government and obtain the rest from contracts for applied research and knowledge transfer. The Austrian Research Centres Siebersdorf (ARCS) have an ownership structure in which central government holds 51% of the shares, while a consortium of the country's leading industrial and commercial organisations retains a 49% interest. The aim of this structure is, once again, to promote linkage with and input from industry. In Spain, a reverse sequence has taken place. Independent non-profit industrial research associations, with their origins in the co-operative movement, have drawn closer to national or regional government. As an example from the regional level, IKERLAN, a private co-operative, has evolved strong links with the regional government of the Basque Country". In terms of research orientation of the research centres the report finds that "***the most frequent orientation is applied research, carried out by almost all labs in the database (705) while basic research is carried out by just over half (388***). Development, diffusion, provision of facilities and certification and standards are further roles undertaken".

Coming to Universities, their organisation, structure and financing has also undergone considerable change within many EU MSs as the following Table (2) indicates.

Table 2: Recent Changes in the Higher Education System in Europe

Austria	2002, The University Act	Provides greater autonomy and freedom to universities. In 2004 they became independent legal entities free to run their own affairs, but with performance agreements between the university and the Ministry of Education, Science and Culture. New funding arrangements are also in place.
Belgium	2003, Decree 4 April	Flanders: Regrouping of universities form 4 to 2; shortening of degree length; new funding system in operation; harmonisation of the higher education system with co-operative formation of entities: hogescholen
Denmark	2003, University Act	Improve flexibility of universities; each university will have its own development contract
France	1999, Innovation Law	The law has allowed the creation of SAICs to structure and manage the valorisation efforts of HEIs; establishment of long term research-industry Technological Research Teams

[57] Concerning UK the report refers to the study of Gummet, P. et al. (2000), which finds that a wide range of science and technology organisations has been subjected to a succession of reviews and many of these, particularly those with basic research as their principal mission, have remained in the public sector.

		(ERT)
Germany	1998, 4th Amendment of the Framework Act for Higher Education, HRG	Broad scope for Lander to be involved in higher education management; reform of HE budgets and decentralisation of control; performance related pay for professor; more support for younger academics; realignment of teaching to Bologna framework.
Greece	2002-6	Supporting entrepreneurial ideas through tertiary education structures.
Ireland	2002-6, National Development Plan (NDP)	Within NDP three new areas relating to higher education: PRTLI Funding of 3rd Level Institutions; Science Foundation Ireland; Commercialisation Fund run by Enterprise Ireland.
Italy	1999, Law 599	Confirms and enhances autonomy of the Universities.
Netherlands	2003, Science White Paper	Introduction of performance related funding of universities (also related to public-private R&D-cooperation) and the transfer of knowledge to society ("valorisation"). This latter role is now one of the three main tasks of universities, and will be clarified and also is explicitly taken up in the new formula for funding of universities.
Norway	2003, Quality Reform	Arising from 2002 the Bernt Commission: commercialisation should an integrated part of a university's and college's remit; new funding formula; internationalisation of Norwegian universities.
Spain	New Law of Universities	New law encourages: mobility of researchers; engagement of professors to undertake mainly R&D; hiring of technicians to support research; establishment of 'mixed' public-private centres in universities; and creation of new start-ups from universities.
Sweden	1996, Higher Education Act	Formal acknowledgement that HEIs should 'co-operate with the surrounding society' confirming the 'third mission' role of universities and colleges.
UK	1999-ongoing	Further changes in 'Third Leg' funding: HEIF – 89 universities been supported in a range of activities including improving intellectual property infrastructure and the creation of 5 University Innovation Centres; Science Enterprise Challenge created in 1999.

Source: CREST Report (2004)

The majority of the policies/schemes illustrated in Table 2 are associated with changes in the HE system in terms of its organisation, finance or in terms of furthering linkages with the private sector. Many of the schemes have focused on the commercialisation of university research and on the need for university funding to be allocated on a competitive basis - most extramural funding, core funding and financing between faculties, tends now to be allocated on the basis of quantitative measures and repeated evaluations. In addition, there is emphasis on management by results (adopted by ministries of education and universities) as a means to increase accountability in universities, raise research standards, give more attention to performance, and increase productivity. On the other hand, a common criticism against management by results is that in its strict application, it gives too much weight to short-term activities and quantitative results at the expense of quality and long-term development[58].

[58] Husso, K., S. Karjalainen & T. Parkkari (eds.) (2000).

3. Commercialization of Research by PREs[59]

3.1 Introduction

As we have already noted, in the last two decades in many countries, institutional, legal and regulatory changes have been inducing universities, and other PRIs to become increasingly involved in the commercialization of their research results - by means of patents and licenses or the creation of new high-tech companies (spin-offs). In the following sections of this Chapter we will present information on the legal and regulatory frameworks that now govern IP at PREs as well as empirical evidence mainly on the amount of commercialization activities and of contract research at PREs in US, Japan, and the EU.

To start with, as Cesaroni and Piccaluga were noting in their recent (December 2003) paper, studies on the resources that the universities devote to the exploitation of research results and on the formal solutions they adopt (industrial liaison offices, technology transfer offices, patent offices, and so on) did not exist, beyond the evidence on this topic for the American institutions.[60] However in the last two to three years a number of reports appeared that provide evidence on the mechanisms through which commercialization takes place and on the results obtained. Cesaroni and Piccaluga (2003) themselves added to this evidence by conducting a survey of 25 Technology Transfer Offices (TTOs) in Italy, while an OECD report published in 2003[61], other reports by the CEU and US Associations and some papers (all of which are reviewed below) have added significantly to our knowledge. [62]

3.2 Trends in IPR Policies at PREs

The desire to increase the economic benefits from public support to R&D has focused policy makers' attention on the laws and rules governing the ownership and exploitation of IP at PREs[63]. The legal framework for IP at PREs in a country is determined generally by five factors[64]:

- ❖ National legislation for intellectual property
- ❖ International and supra-national IP rights regimes
- ❖ Employment laws
- ❖ Research funding regulations
- ❖ Contract law

Table 3 below summarizes the legal basis governing the ownership of IP at PREs in a number of countries.

---

[59] The Tables and Figures referred to in this and the next chapter are mostly included in Appendix 5 of Part II.
[60] Page 2-3. For US evidence the authors refer to the study of Sigel et.al., 2000.
[61] OECD (2003), "Turning Science into Business". Nevertheless it should be noted that only the US and the UK have been regularly collecting data on IP in the public research sector. Consequently, the data on which the analysis presented is based do not provide a complete time-series information on patenting and licensing activity or data which cover all the categories of public research commercialization for other countries. As a result, comparisons across countries should be undertaken with care. OECD (2003) data, in particular cover only a limited number of the EU-15 countries (see also below).
[62] It is worth stressing here the significant reliance of this section (and more specifically of the next 12 pages) on the empirical information provided by the above articles and reports, particularly the OECD (2003) report.
[63] Note that the OECD (2003) report uses generally "PRO" rather than our "PRE".
[64] OECD (2003), pages 22-23.

Table 3: Legal basis governing the ownership of IP at PREs in selected OECD countries

	IP-related legislation	*Employment-based laws*	*Government research regulations*
Austria	Austria patent law grants ownership of employee inventions to the employer. In the case of Universities the employer is the Austrian government represented by the Ministry of Science.		A new university law in 2002 assigned title of inventions at universities to the institution.
Belgium	Federal Law on Industry Property and IP. Universities fall under competence of "community" governments. In Flanders all IP from University researchers belong to University. Since 1998 universities in the Waloon region can own the results of research that is fully funded by the region.		1999 Decree on Education was adopted to create a framework for IP at universities. Decree regulates
Canada	The Patent Act (R.S. 1985, c. P-4) requires that government Crown employees who, acting within the scope of duties and employment, invent any invention in instruments or war munitions, can be required by the Defence Ministry to assign rights to benefits of the invention and of any patent obtained ot to be obtained for the invention subject to compensation. Copyright Act (R.5. 1985, s.c. C-30, s. 1) states that, in the absence of any agreement, employers retain copyright to works created under a contract of service or apprenticeship. Authors of articles or similar contributions to a newspaper, magazine or similar periodical shall, in the absence of any agreement to the contrary, reserve a right to restrain the publication of the work.		1991 Crown Procurement Policy stipulates that IP resulting from Crown procurement contracts remain with the contractor. In 2000, the policy was revised to re-affirm its application to all government contracts for goods and services, remove ambiguities and include a mechanism to deal with complex IP ownership situations by identifying the rights and obligations of all parties involved.
Denmark	Act on Inventions at Public Research Institutions (2000) grants title to PRO but allows inventor right of first refusal. Consolidated Act on copyright regulates ownership of literary and artistic works. Copyright at PROs is governed by rules that govern copyright ownership in		

	private enterprises.		
France	Article L.6111-6 of the French Intellectual Property Code stipulates that inventions made by salaried employees, both in the public and private sector, in the context of the employee's functions shall belong to the employer but the employee has a right to additional compensation.		
Germany		2001 Reform of Employee Law has rendered university inventions "service inventions" which means they now belong to the university.	New federal regulations grant PREs title to inventions arising from government funded research, 1998.
Ireland		Employment law provides for employers to retain title to inventions by employees except as otherwise agreed in contracts.	
Italy	Article 7 of National Law No. 383 of 18 October 2001 assigns title of inventions at universities to researchers.		
Japan	1998 Technology Transfer Act; Article 15 Copyright Act grants employer (legal person) authorship rights for works by employees made public under the name of the employer (legal person) unless otherwise stipulated by contract.		Invention committees at national universities decide whether the government or the university inventors retain title to the invention. Government regulations on contract research between national universities and firms give the latter the right to retain up to half of the IPR.
Korea	Under the General Patent Law Amendment (2001) PROs can claim private property and operate an independent budget and accounting.		The Regulation on Management of Publicly Funded Research (2001) gives the main research institute ownership of IP and sets forth rules how the income generated should be used.
Netherlands	Dutch Patent Act grants PROs title unless agreed otherwise by contract.		
Norway	General patents Act 1967.	Act on Employers Right to Commercialise Inventions Made by Employees, 1970	

Russia	The Patent Law, amended on 7 February 2003, establishes that IP developed with state funds belongs to the PRO if a state contract does not stipulate ownership by the Russian Federation on behalf of a state client represented by a ministry. Executive and legislative decrees oblige government ministries to claim ownership of patented and non-patented IP but in the framework of a state contract and do not establish in which cases the government ministries can assign their IP rights to a PRO.	The Patent Law establishes that right to a patent for an invention, utility model or industrial design, created by an employee (author) in connection with execution of his duties or a specific assignment belongs to the employer if not otherwise specified by an agreement.	The Law on Science and State S&T Policy establishes that the use of results of scientific research of the Russian Academy of Sciences, conducted with federal budget resources is determined by legislation of the Russian Federation. The legislation does not contain any special standards, regulating relations with respects to ownership by the Russian Academy of Sciences of the IP created with the use of state budget.
South Africa			No IP legislation for funding.
Spain	Article 12-20 of the Spanish Patent Law (1986) regulates ownership of inventions in companies and public organizations. It indicates that universities will apply for patents resulting from research of professors.		
Switzerland	Federal laws concerning patents, copyrights, design, trademarks, plant varieties and integrated circuits are applicable for all organizations, but public rules can complement and modify ownership rights.	The Federal employer law grants IP rights for patents, design and plant varieties to the employer. This rule is generally not applicable to the public sector, unless public rules specifically refer to it.	Swiss National Science Foundation grants IP ownership to researcher respectively to their employees; Federal Research Law does not specify IP ownership rights.
UK	1977 Patent Act and 1988 Copyright Act indicate that IP generated in the normal course of employment shall belong to the employer. Recent guidelines by the UK Patent Office reaffirm that IP generated in publicly funded research should generally be vested in the organization that does the research.		Health Service Circular (HSC 1998/106) of the National Health Service Trust (NHS) stipulates that IP arising from R&D funded by the R&D Levy normally resides with the organization (e.g. university, commercial organization, NHS body) carrying out the R&D and capable of exploiting the resulting IP. A new framework and guidance document has been established for hospital employees and other health workers (www.innovations.nhs.uk)
US	The Bay-Dole Act allows individuals (researchers, scientists, etc.), whose work resulted in the creation of an invention and was partially or completely financed through		The 1980 Stevenson Wydler Innovation Act – and subsequent amendments to the Act – authorized federal laboratories to conduct cooperative research and development agreements (GRADAs)

federal funds, to own inventions; 35 USC (United States Code) 202 applies this policy to non-profit organizations, including universities.		with private firms and to allow licenses to these firms.

Source: OECD (2003), pages 24-25.

One could identify the beginning of the transition to the new rules governing IP ownership and exploitation of the results of public research in 1980 when the Bayh-Dole Act in the United States gave universities the right to take out patents on inventions and license them to firms. Policy trends in many countries in the last two decades follow in the footsteps of the landmark US Bayh-Dole Act. In many countries it is only recently (last 6 to 7 years) that changes have been occurring. Thus, Austria, Denmark and Germany have recently introduced new legislation to grant universities title to IP resulting from publicly funded research. In Japan and Korea, recent reforms in funding regulations have given universities more control over the IP generated by their researchers. It is worthwhile noting that unlike the US Bayh-Dole Act, in some EU countries legislation amendments have focused on employment law specifically on the rights of university professors. As noted in the OECD (2003) report "In most (EU countries), ownership of IPR at non-university PROs generally devolves to the institution. Several EU countries have a dual system whereby title is granted to professors (inventors) at universities while the institutions retain title at non-university PREs. For example, in Norway (until 2003) and Finland, the employees of non-university PREs do not retain title to patented inventions, but a professor employed by a university does. This was also the case in Germany until 2002"[65].

Considering the pros and cons of granting IP ownership to researchers and institutions, the former has the ***advantage of creating greater incentives for disclosing and commercializing inventions*** but has the ***disadvantage that the costs for patent protection are generally too high*** for individual (or small groups of) researchers. Further when, as is often the case, the invention involves many researchers, the system of granting IP ownership to the researchers has the disadvantage that firms may prefer to have to deal with a single IP holder – this lowers transactions costs, provides greater legal certainty and makes the technology transfer and licensing process more efficient. These considerations explain why in a number of countries the system that has emerged is one in which IP ownership is granted to the institution while ensuring that royalties are shared with the researchers/inventors[66].

3.3 Technology Transfer Offices (TTOs): Evolution, Structures, Prevailing Activities and Support by Governments

3.3.1 TTOs: Evolution and Structures

Technology Transfer Offices (TTOs), or Technology Licensing Offices (TLOs), in PREs, have existed in significant numbers since the mid-20th century. Nevertheless, most TTOs are recent; their mean age in the **US** is 12 years. Following the enactment of the Bayh-Dole Act the creation of specialized offices became essential to the

[65] OECD (2003), page 23.
[66] See OECD (2003) report, pages 23-26.

management and exploitation of IP in PREs. Today, most US Universities and PRIs have TTOs and their numbers continue to rise[67].

Concerning the EU MSs, in **Italy a**s shown by Cesaroni and Piccaluga's (2003) survey most universities have created TTOs only in the last 3-4 years with an average number of employees of only 1.44 persons[68]. In **UK**, the majority of institutions (61%) created a specific unit or team to act as the interface between the university and business between 1996 and 2003. According to the *UNICO-NUBS Survey 2003*[69] over 80% of institutions have at least 2 full time equivalent employees (FTEs) in commercialisation activities. In **Germany**, since the abolishment of the university teachers´ privilege in 2002, the government promoted the establishment of patent and exploitation agencies (*Patent- und Verwertungsagenturen PVA*) on behalf of the universities. In mid-November of 2003 the Federal Government announced its decision to extend the funding programme to support regional PVAs in Germany. EUR 28 million has been earmarked for the three-year period 2004-2006. The PVAs were established under a EUR 50 million programme to promote the commercialisation of university research. Since the beginning of 2001, the German Government spent EUR 22.3 million to establish 20 patent exploitation agencies representing 245 universities[70]. At non-university PREs many of TTOs in Germany were created by the early 1990s. The patent and licensing branch of the Max Planck Society, which is responsible for commercialising the research generated in some 70 Max Planck research facilities, was founded as Garching Instruments in 1970 – and renamed Garching Innovation in 1993[71]. The Fraunhofer Patent Centre PST is responsible for commercialising research carried out at the 58 Fraunhofer Institutes across Germany since its founding in 1955. The centre also implements a number of knowledge transfer and commercialisation initiatives on behalf of the Federal and some Länder Governments[72]. The members of the Helmholtz Association, Germany's 15 national science centres, have their own technology transfer departments. Research generated in the Helmholtz centres specialising in the life sciences is commercialised by Ascenion GmbH[73]. In **Spain**, the Spanish General Directorate of Scientific and Technical Research (within the Ministry of Education and Science) in collaboration with the general secretariat of the National Plan for Scientific Research and Technological Development has established a network of Offices for the Transfer of Research Results (OTR). These offices are located within universities and research centres, and are co-ordinated by a national Technology Transfer Agency (OTT). Thus the University of Aragon had an OTR established in 1986 to help stimulate technology transfer within the region (Sanchez and Tejedor 1995)[74]. The functions of this network are to encourage the external transfer of R&D results to industry, and to provide support and advice to researchers in the institutions on legal aspects of research and on gaining research funding, especially from the European Commission.

---

[67]OECD, 2003, p.37. As noted, Germany's Fraunhofer Society's TTO was founded in 1952 while in the United States, the University of California system founded an office for technology transfer in 1926.

[68] Cesaroni, Fabrizio and Piccaluga, Andrea, 2003. The first institution which formally created a TTO in Italy is the University of Bologna, which launched this activity in 1989. Most TTOS were created just before the law on the employee ownership changed to grant title to inventors rather than universities.

[69] Unico, *UK University Commercialisation Survey: Financial Year 2003*, August 2004.

[70] See M.O. Sellenthin (2004), "Universities in Innovation Networks: The impact of supporting infrastructure on the incentives of researchers".

[71] See http://www.garching-innovation.de

[72] See http://www.pst.fraunhofer.de

[73] See http://www.helmholtz.de and http://www.ascenion.de

[74] Sanchez, A. M. and Tejedor, A-C. P. (1995).

In **Japan**, the creation of Technology Licensing Organizations (TLOs) is a recent development – over 90% were established after 1990. The number of TLOs reached 37 as of July 2004 (Figure 1)[75]. The oldest of these is the Center for Advanced Science and Technology Incubation (CASTI)[76] which is associated with Tokyo University and was established in December of 1998. In 1999 the enactment of the Japanese Bayh-Dole Act brought the shift of IP rights from the individual inventors to the organizations for which they work, which prompted the government to think about establishing TLOs in each university and the establishment of the Intellectual Properties Strategy Center in March 2003, which produced an action plan in July 2003. Under the action plan and following an extensive review, 43 universities were granted an average $462,000 per five years for establishing University Intellectual Property Centers[77].

Concerning the **structure of TTOs**, a number of different institutional arrangements have been used for organizing TTOs in different countries. Consequently, the question that emerges is which is the optimal institutional arrangement? Concluding its survey on this issue the OECD report notes that "The answer is not altogether clear as the relation of a TTO, or a similar body, to the PRE depends on several factors. One is the legal environment; PREs that can claim title to inventions have a greater incentive to develop such structures. Another is the university's or research institute's degree of institutional autonomy and the existence of laws and regulations (e.g. fiscal status of PREs) that require the PRE to adopt alternatives to in-house operations. To illustrate many US public and state-chartered universities have established arms-length institutions (e.g. foundations) because they generally benefit from the immunity from prosecution granted to state governments. In Japan, national universities are not autonomous and there as well TLOs have been established as separate and private entities…... Until recently, many European countries prohibited public universities from having equity participation in spin-offs. The UK changed a law prohibiting universities from keeping revenue from commercialization. Previously, licensing revenues were transferred to the Treasury. ***The appropriateness of one institutional arrangement or another depends on the context in which the PRE operates:*** its status as a private or public institution, the amount of government funding it receives, the size of its research portfolio and fields of specialization, its geographical proximity to firms and its funding capacity"[78].

3.3.2 Prevailing activities of TTOs in the EU

DG Enterprise, together with a consortium of European companies, has recently compiled a catalogue of TTOs in Europe[79] and examined the main type of activities undertaken by them. The report breaks down TTOs into the following categories:

---

[75] Appendix 5 of Part II

[76] See http:www.casti.co.jp

[77] The list of the 43 University Intellectual Property Centers can be seen at http://www.nsftokyo.org/rm04-05.html

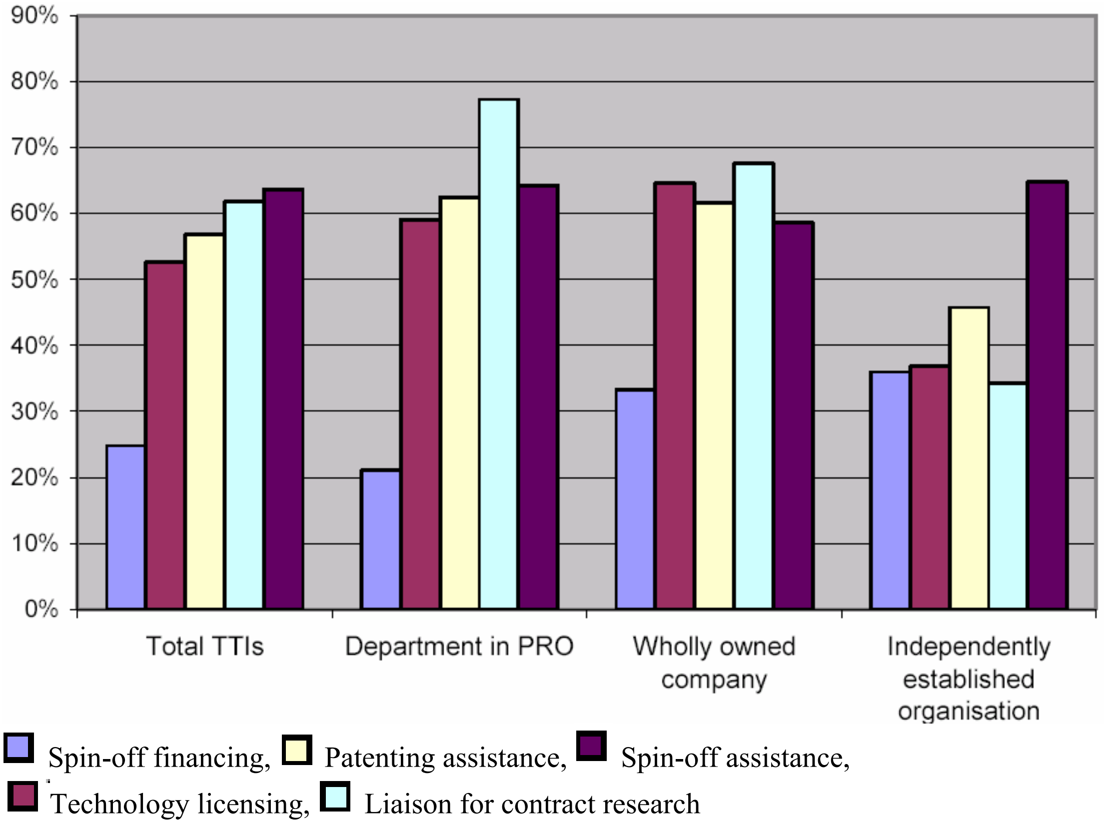
[78] OECD, (2003), page 39-40. The report refers to the *Interim Results of the TIP Project on the Strategic Use of IPR at PROs*, Internal OECD Working Doc, 2002.

[79] European Commission, *Improving institutions for the transfer of technology from science to enterprises, Expert group report Conclusions and recommendations*, BEST PROJECT ITTE 1.11/2002, July 2004. The database lists over 1,500 institutions and organisations based in the current MSs and new Member States, along with searchable contact information. Where available, the catalogue also provides additional information on the types of activity, as well as scientific and technological fields covered. TTOs are identified in the catalogue as: organisations or parts of an organisation which help the staff at public research organisations to identify and manage the organisation's intellectual assets; organisations that help staff at PROs to create new companies in order to develop

- "Department-type" (54%) - organisational units or specialised departments within the PRE.
- "Wholly owned-type" (14%) – they operate outside of the PREs but are wholly owned by them
- "Independent-type" (32%) - public or private independent intermediaries serving one or more PREs

Concerning the activities undertaken by the different TTO categories, the report finds that (see Figure 2 below) "the prevailing activity in department-type and wholly owned-type TTOs is liaison for contract research. On the contrary, this activity is not performed very often by the independent-type TTOs which rather focus on spin-off and patenting assistance. However, there are some similarities in all of the three models of TTIs. Management of contract research is not necessarily combined with patenting and licensing activities. A possible explanation is that IPRs resulting from contract research usually belong to or are exploited by the contractor and not by the PRO. Although all empirical evidence emphasizes the importance of the existence of financing mechanisms, such as venture capital funds providing seed financing to spin-offs, only a small part of the TTOs that support spin-offs offer such a possibility".

Figure 2: Type of activities mainly performed by different models of TTIs including Technology Parks and Incubators – EU-15 countries



or commercialise an invention; and those contract research organisations providing research services to the private sector that have a specific technology transfer function. 1,596 European institutions were identified within the framework of the project, of which 1,393 qualified as TTOs according to the project's definition. The remaining 203 institutions were contract research organizations or science parks, which had either no separate transfer organization or provided only services such as information brokering or consulting.

Comparing EU countries on the basis of the activities of their TTOs[80], the report identifies a number of specialisation patterns. Specifically, "Three countries rate above average for all the examined activities, namely: Belgium, the Netherlands and the UK. Also the UK and Belgium have the highest percentage of TTIs in two areas of activities. Greece, Italy and France are at the other end, ranking above average in only one activity. The UK is the country that puts the highest emphasis on patenting assistance. Similarly, Belgium puts the highest emphasis on technology licensing. Ireland comes first in liaising contract research, the UK in spin-off assistance and Belgium, again, in spin-off financing. Countries could also be clustered based on the specialisation within the country, which leads to the following country groups:

- *Liaison for contract research*: Austria, Germany, Greece, Ireland, Spain, the Netherlands
- *Technology licensing*: Belgium, Denmark, the Netherlands
- *Spin-off assistance*: Finland, Italy, Portugal, Sweden, the UK
- *Patenting assistance*: France."

3.3.3 Government support for TTOs

Governments, beyond determining the legal framework for IP issues at PREs, can also influence through various forms of support the viability of TTOs. Indeed the OECD (2003) survey stresses that "One of the challenges that institutions and governments face…… is sustaining the viability of technology transfer operations. ***Even in the US, few TLOs generate sufficient licence income to exceed expenditures*** (Nelsen, 1998). ***Those that have become profitable have done so after five to ten years of their operation and with long term investments in management and marketing*** (Kneller, 2001). While some PRIs in Europe, such as the UK's Medical Research Council Germany's Max Planck Society and Belgium's IMEC, are quite successful in terms of patenting and licensing, technology transfer operations at universities are more recent and….. are spurred by government support"[81]. It should be stressed that ***low incentives to patent and license are often the result of "the high costs of patenting and licensing, and the uncertainty over the potential revenue from licensing"***[82].

A number of measures have been used in different countries[83]:

- ❖ The German Ministry of Science and Technology (BMBF) in early 2002 launched a multi-million euro program to assist universities in hiring external services for licensing and prosecution of IP (Gering at al., 2002)[84].
- ❖ In France the Innovation Law of 1999 provides for the strengthening of TTO structures at universities notably for the creation of departments for commercial and industrial services.
- ❖ The Japanese government has subsidized since 1998 the newly created TLOs to provide university inventors with IP management and commercialization services.
- ❖ To strengthen capacity in TTOs, the Belgian government provided €1.25 million a year over five years to help six PROs (of which three are universities) develop, implement and evaluate annual work plans for technology transfer.

---

[80] See also Table I in Appendix 4 of Part II.

[81] OECD (2003), page 44. Kneller, R., *Technology Transfer: A Review for Biomedical Researchers*, Clinical Cancer Research, Vol.7.

[82] Page 44.

[83] See the OECD (2003) report, page 44.

[84] Gering, T., Schmoch, U. and Werner, O., OECD, Paris, 2002 – referred by OECD (2003).

- In Denmark, a grant of €8 million was set aside for the period 2000-2003 to help universities and other PREs protect and market their inventions.
- In the UK, some PREs, with government support, have developed a partnership to pool resources and increase the rate at which they market their IP in the health and life science fields[85].
- Further: "Governments encourage PRE patenting activity by lowering or subsidizing the cost of patent protection. ***Patent costs are lower in the US and Japan than those for filing a patent at the European Patent Office (EPO) with protection in several European countries…... (Thus) the advent of a single, cost-efficient European patent could help widen the market for commercialising PRE inventions in Europe"[86].***
- Finally, another kind of public support is in the form of legal training of TTOs staff. "***Well-trained staff at TTOs is not only essential to the efficiency of technology transfer but can also help to limit conflicts of interest with researchers. One of the main challenges facing PREs is to attract and retain the human resources to manage TTOs and interact with scientists"[87].*** In many countries, governments have recently either through direct schemes or via national patent offices supported IP training at PREs.

3.4 Trends in patenting, licensing and spin-offs

This section deals with the question of the extent to which the changes in the institutional, legal and regulatory frameworks and the growth in the establishment of TTOs, which were reported in the previous sections, have had an impact on the commercialization activities of PREs – specifically, their patenting, licensing and spin-offs creation activities.

3.4.1 Patenting activities of TTOs

As already noted above and as the OECD (2003) survey testifies while many countries have some evidence that the patenting activities of their PREs have been

---

85 The OECD report refers to the DTI, *White Paper on Science and Technology*, 2000. According to this a network of hub organizations is being established across England to manage IP coming out of hospitals and other health organizations. These hub organizations receive public funding by the DTI, by the Department of Health, the English Regional Development Agencies and others..

86 OECD (2003), pages 44-45. The report notes that "in Germany a university pays €3,000 - 4,000 for application and attorney fees to fill a national patent claim, while a European Patent Convention (EPC) patent costs €50,000. European PROs tend to file most of their patents in their home country and fewer academic patents are filed at European level or overseas. This likely reflects the importance of filing within home jurisdictions first, but there are concerns that subsequent patenting at EU level could be deterred by the costs of an EPC patent. The higher costs may also serve as litmus test: if the potential commercial value of the invention is high, the incentive to seek protection in foreign markets may also be high, despite the high patent costs". Concerning measures towards patent costs, the report notes that in Japan, the 1998 Technology Transfer Law exempts "acknowledged" TLOs (*nintei* TLO) from paying patent application fees and annual patent and examination fees, or reduces these expenses by 50% for three years. In the US, the United States Patent and Trademark Office (USPTO) offers reduced patent fees to small entities with fewer than 500 employees. Since 1995, the USPTO also permits a provisional patent application which is particularly useful for universities and small firms, as it allows them to obtain early protection of an invention without preventing the researcher from publishing its results. This is important if protection is to be sought in foreign jurisdictions with first-to-file patent systems. The EU also allows patent costs to be eligible costs included in the indirect research expenditures for Community Framework grants.

87 OECD (2003), page 46. As the report notes, "Since 1998, the German government sponsors training schemes at universities. The UK patent office actively promotes awareness of IP management at PROs and diffuses information on good practices. Switzerland's Network for Innovation sponsors training on IP matters and the government indirectly sponsors the IP activities of PREs such as the federal institutes of technology. Enterprise Ireland provides short training seminars on technology transfer and IP related matters through its Campus Company Programme. The USPTO and the Japan Patent Office also offer regular training courses on IP management to small businesses and organizations".

rising, few have undertaken comprehensive surveys to obtain an accurate and complete picture of patenting activity and the number of active patents under management by their PREs.

It is useful to start by noting that University patenting is not a new phenomenon and to consider first the situation in USA. As mentioned by Cesaroni and Piccaluga (C&P; 2003), "in the US, universities and other PRIs have been active in patenting for a long time, since the earliest years of the 20th century (Mowery and Sampat, 2001). However, since the late 1980s, the number of patents from PROs has significantly increased (Jaffe, 2000; Carlsson and Fridh, 2000)"[88]. It is not clear however to what extent (i) the increase is due to the passage of the Bayh-Dole Act and (ii) the increase reflects an equally significant increase in the "useful knowledge" patented. Though the Act must have made an important contribution, the increase in patenting also reflects the fact that the number of institutions applying for patents has also increased – form 30 in 1965 to 400 in 1997[89]. Most importantly, the increase in patenting "has been accompanied by a decline in the average patent "quality", mainly resulting from a lower average quality of patents obtained by these institutions which were newcomers in patenting activities"[90].

Further, as hinted in the first Chapter of this Part above, it is worth stressing here that the increase in patenting by PREs could conceal negative consequences too. Thus excessive attention on patenting may:

(i) reduce resources devoted to fundamental research
(ii) produce undue delays in the publication of research results[91]

Concerns about the role of patenting by PREs found distinguished support recently in Nelson (2002)[92]. He notes that while US Universities have been spurring technological progress in industry for over a century, it is presently widely believed that it is the recent growth in university patenting that is the key to universities inducing industrial innovation. He argues that:

- University patenting is neither sufficient nor necessary for technology transfer to industry - indeed it is a "myth" to think that it is necessary in most cases.
- While in some cases patenting is useful in other cases it is counterproductive
- While the Bayh-Dole increased patenting, the increase has also been due to "development and maturation of new fields of science and new techniques – molecular biology and biotech, electronics, computation, instrumentation, software".
- It is a "myth" that university patenting will greatly help universities financially, while it may lead to "internal university conflicts and conflicts of interest, it can damage relationships with industry and it can threaten rationale for public support".

Coming now to *evidence from other countries*, the OECD (2003) survey provides data on the total stock of patents for which TTOs are currently responsible and the number of patents granted to the institution for eight European counties (Belgium, Denmark,

[88] Page 3. They note that between 1969 and 1997 the University of Califirna received the most patents (1937), followed by MIT (1871) . In 1999 alone the former received 437 patents and MIT 142 patents.
[89] C&P, p.3. They refer to evidence provided by Henderson et. al. (1998).
[90] Ibid., p.3. As they note, the frequency of citations received is the measure of patent "quality".
[91] C&P cite (page 5) a number of authors that have expressed such concerns: Florida, 1999; Salter et.al., 2000; Guena and Nesta, 2003 and Nelson, 2002).
[92] "The Contribution of American Research Universities to Technological Progress in Industry".

Germany, Italy, the Netherlands, Spain), Australia, Japan, Korea, Norway, Russia, Switzerland and USA[93]. Further detailed information on patenting activity as well as on spin-offs and other IP actions in UK & USA, the two countries for which the largest amount of information can be found, is included in Appendix 1 of Part II.

The OECD survey produced the following main results:

i. Stock of patents at TTOs
   - this ranges from less than five to a few dozen (Figure 3)[94]
   - 70% of the Swiss and Italian Universities and 40% of the Korean ones reported managing fewer than 50 active patents
   - portfolio sizes do not exceed ten patents in 50% of PRIs in Germany and over 20% in Korea or Italy
   - 50% of all PREs in the Netherlands, Spain and Belgium manage portfolios of fewer than 50 patents

ii. Patenting activity in previous year (2000 or 2001)
   - it is not uncommon for 20-30% of TTOs not to obtain a single patent in a given year (Figure 4)
   - the majority of PREs received on average fewer than five patents in the previous year
   - PRIs seem to be slightly more active in patenting than universities

iii. Patent applications
   - the number of patent applications per TTO (usually more numerous than grants) ranged from an average of less than ten a year to several dozen (Figure 5).
   - in exceptional cases, the US federal laboratories for example, there were a couple of hundred patent applications. However, the size of the PREs must be taken into account when comparing these figures.

iv. In Germany, a more precise picture of PREs could be provided. Given their volume of R&D, it is not surprising that universities apply[95] for more patents than the other PREs considered (Figure 6). Since 1970, the number of university patents has steadily increased. This is only due in part to an increase in their research activities. The emphasis by universities on the exploitation of their research results has also gained importance. Among PRIs, Helmholtz centres have always actively patented, and their patenting has increased since the beginning of the 1990's. Like universities, they have changed their orientation towards technological exploitation. The Max Planck Society focused on basic research. The number of patent applications is therefore low in relation to its research volume. Nevertheless, there is a general upward trend in the filing of the patent applications over the last decade. Although the Fraunhofer Society's research volume is modest, it contributes significantly to patent applications of PREs. Its share increased during the 1990's. At present, the number of Fraunhofer patent applications is comparable to that of the Helmholtz Association. This is linked to the institution's focus on applied

[93] OECD, 2003, page 50. The data specifically refer to "currently active technically unique patents". "Currently active" means that the patents are still the property of the PRE: they have not expired, been elapsed or been sold. "Technically unique" means that patents for a single invention filed in multiple jurisdictions (e.g. EPO and Japanese Patent Office) should not be double or multiple counted as separate patents. The objective is to see how many unique patented inventions are under management by the organization.

[94] Appendix 5 of PART II. The Figures and Tables referred to below are all in this Appendix.

[95] University applications in this context are those developed in universities and in particular by the teaching staff. Most of these patent applications are not owned by the universities..

research and technology transfer. All in all, patent activities by German PREs increased markedly in the 1990's.

Cesaroni and Piccaluga (2003) have analysed the patents granted to PRIs in the Southern European countries – namely Italy, France, Spain, Greece and Portugal – from the European Patent Office (EPO) and the US Patent Office (USPTO) during the period 1982-2002. By looking at their evolution over time (see also Figure 7), the main conclusion that emerges is that "in the Southern European research institutions there is a combination of two converging factors: a small propensity to patent by any research institution and a small number of institutions actively involved in patenting. Indeed, in each country, the number of PREs that have been granted at least one patent is rather low and only few of them have been granted more than 20 patents over the last two decades" (Table 4). Concerning individual countries, in France 16 PREs hold at least one patent, the first one being CNRS with 683 patents and a share of 75% of all French public patents (the second one with only 41). In Italy 12 institutions hold at least one patent, the CNR owns a total of 291 patents – 39.2% of the total – which is therefore much less than the share of the French CNRS, and the first five institutions own 86% of all patents, as in France. In Spain, only 6 institutions hold at least one patent and the first PRE is CSIC with 63 patents (50%). The first five institutions have a share of 86% which is very close to the values of France and Italy which therefore have very similar concentration patterns. The distribution of patterns is also quite concentrated in Greece and Portugal where the leading patenting institution owns more than 70% of the total PREs' patents, showing that patenting in these countries is more the result of the effort of these institutions rather than that of the whole national research system.

What then has been the overall trend in patenting activities? It would seem that mainly in countries other than the USA, especially if we remove from the picture the very few dominant PRIs in each country, the changes in the legal framework have not yet had a significant effect. While much "of the focus of the reforms in the legal frameworks has been on the issue of transferring ownership of IP to the performing institution ***…. in countries where the PREs have owned the IP, patenting activity by institutions has nevertheless been weak. Partly, the reason for this is that PREs have not had sufficient incentives …. to disclose, protect and actively commercialize IP"[96].*** As the OECD survey finds ***"Non-IP related laws and regulations can be a barrier to technology transfer as well as fiscal rules that prevent PREs from receiving and retaining royalty income from licenses*** such as those recently lifted in the UK and Korea. However, experience suggests that while legislation may sometimes be necessary to create the incentives for PREs to protect and commercialize IP, new laws are not the only action that can be taken. The Irish and Canadian governments have sought to improve coherence and clarity for managing IP at PREs by modifying or clarifying existing policies among the different stakeholders. In countries that have implemented policies by legislative means or otherwise, one of the main impacts has been to raise awareness of and support for technology transfer, especially within the hierarchy of PREs and among researchers and graduate students"[97].

[96] OECD (2003), page 11.
[97] Ibid., page 35.

3.4.2 Non-patent IP actions undertaken by TTOs

Applying for patents is only one of a range of actions that TTOs can take to help protect and exploit their institution's intellectual property. A first step may be to receive "invention disclosures"[98] by inventing scientists, which is an indicator of the potential for new patents. TTOs in US PREs reported the greatest number of disclosures (16286), while in Germany PRIs reported 948 disclosures, Japanese Universities 489 and Switzerland PREs reported 280[99].

Other non-patent IP actions (such as copyright registration, protecting industrial design etc) are reported in Table 11 indicating that TTOs engage to some extent in all these activities. TTOs reporting the number of non-patent actions undertaken in the last year (Table 12) reveal again that obtaining invention disclosures and negotiating non-disclosure and confidentiality agreements ranks first by far.

3.4.3 Spin-offs as a form of technology transfer

PREs, rather than license their inventions to other organizations, they can form new technology-intensive firms. Table 17 shows the total number of spin-offs and start-ups reported by the TTOs in the OECD survey (years 2000 or 2001)[100]. ***In half of the reporting countries, the average number of new spin-offs or start-ups reported is under one a year per TTO***[101]. The highest number among European countries is in Switzerland (2.3 per year per TTO) followed by Netherlands (just over one) – while US averages 2 per year.

For the period 1996-2000 a rapid pace in the founding of spin-offs is recorded in Germany[102]. An average of some 2,500 "transfer spin-offs," approximately 4,200 "competence spin-offs" and around 30,000 academic start-ups were founded every year[103]. When transfer spin-offs are broken down by industry we see that those branches of industry that fall under the category of technology-oriented services accounted for the largest share of spin-off/start-ups - which has risen steadily in the years since 1997. The number of companies founded in other knowledge-intensive services was somewhat smaller (Figure 8). Although the curve for this latter group moved both up and down over the five-year period, it exhibits an overall upward trend. On the other hand, the ***R&D intensive branches of the manufacturing sector – in other words, branches of cutting-edge technology and advanced technology – generated far fewer spin-offs. The number of spin-offs founded in these branches each year remained relatively constant during the period 1996 through 2001.***

[98] Further details concerning issues related to invention disclosures are included in Appendix 2 to Part II.

[99] OECD (2003), page 14.

[100] The OECD (2003) survey distinguishes between a spin-off - a company that includes among its founding members a person affiliated with a PRO – e.g. a professor or researcher and a start-up - a firm that is not founded by a staff member of the PRO but is developing technology originating at a PRO – e.g. a technology licensed from the PRO. Both definitions are included because countries differ in their definition of spin-offs and start-ups. Many PROs do not yet monitor the formation of spin-offs or start-ups despite their potential economic importance. As a consequence, the response rates to this question were typically low.

[101] This includes all the TTOs reporting the creation of no firms of this type but not those that did not answer the question or did not know.

[102] Federal Ministry of Education and Research, (2002).

[103] The founders' research findings are indispensable to transfer spin-offs. In the case of competence spin-offs, it is the founders' expertise. In contrast, scientific methods and findings are not particularly important for academic start-ups.

In Japan where the government has been supporting new spin-off company creation from universities by de-regulation and by providing subsidies to R&D activities[104], in 2000, there were 127 new enterprises spun-off from universities, which compares to 424 in the US in 2000 and approximately 200 in UK. In 2001, 251 and in 2002 424 small business companies were created from universities in Japan (Nakagawa, 2003)[105]. Japan seems to be following the 'US model' with emphasis on licensing and start-ups from universities while it has tended to underestimate the role of existing informal links between universities and business.

3.5 TTO licensing practices

The OECD (2003) survey explored the licensing practices of TTOs[106]. The main findings obtained were as follows:

i. Two thirds of TTOs report that their PREs negotiated less than 10 licenses a year (Table 23). The other third report that PREs negotiate between 15 (Netherlands) and 46 (Switzerland) licenses a year – in US average is 24 and in Germany 19.
ii. Concerning the breakdown of licenses by type of IP it is interesting to find that ***patented inventions are not the most frequent object of licenses*** (Table 24). Korea was the only country where this is not true. In the other countries, technologies for which patents are pending and non-patented inventions are more frequently the object of a licence. "***Licenses for inventions with patent pending are especially significant because they are an indicator that TTOs license early-stage technologies to firms that subsequently invest in their further development.*** The large percentage of licenses for non-patented inventions in Italy, Japan, the Netherlands and Switzerland is interesting as this runs counter the hypothesis that licensees prefer to license strong forms of IP with guaranteed market exclusivity"[107].
iii. The extent to which PREs grant exclusive rather than non-exclusive licenses varies widely (Table 25). Limited exclusivity licenses help ensure that a technology is used more broadly. However, firms may require an exclusive licence in order to commit to the necessary further investments in commercialising a technology. "***For some countries, exclusive licenses are rarely granted, while in others they are quite common – Italian PRIs, the Netherlands, Japan and Belgium.*** Nevertheless, PROs frequently limit the rights of their licenses in some way. ***All countries indicate that their PREs use time-limited, territory-limited or market/field-limited exclusivity to a certain extent.*** In Germany and the Netherlands, for example, these types of limited licenses are relatively common with over 50% of TTOs reporting their use in the past year. Most other countries report their use by one-quarter to

[104] Fumi Kitagawa, (2004).
[105] Nakagawa, T (2003), http://www.rieti.go.jp/users/cluster-seminar/pdf/003_p_en.pdf , 22/04/04.
[106] Specifically, TTOs were asked for the number of licenses negotiated in the last year and the type of IP licensed. Licenses can be granted for the use of patented technologies, technologies with a patent pending, for unpatented technologies for which no formal form of protection has been or will be sought (e.g. biological materials or know-how), for inventions covered by a generic form of protection (plant varieties) or to creative works covered by copyright. Countries appear to be divided into two broad categories.
[107] OECD (2003), page 63. Equally surprising is the number of countries for which copyright is an important category of licensed IP. Germany, the Netherlands, Spain, Switzerland and the Italian PRIs all reported that 25% or more of their licenses involved copyright. In Spain and the Netherlands, the number of copyright licenses far exceeded licenses for patented, patent pending and not patented technologies.

one-third of their PRIs. The wide dissemination of technologies through non-exclusive licensing is reported as common practice by Germany, Netherlands and Swiss PRIs. However, less than 50% of PRIs in Italy, Japan, Korea, Spain and Swiss universities report having issued any non-exclusive licenses"[108].

3.6 PRE revenues from commercial activities and contract research

The OECD (2003) survey also considered a number of indicators of the income-earning capacity of PREs from licensing IP[109]. The main results were as follows:

i. As Table 28 shows, per TTO, there is a wide range in the number of licenses that earn income. ***The median number of licenses earning income at most TTOs is quite low.*** Looking at the median number of income earning licenses, only Japanese and Spanish PREs, German and Italian PRIs and Korean Universities report more than one income earning license per institution.
ii. Also, from Table 28, it is apparent that PRIs are much better than universities in terms of the average number of licenses earning income.
iii. ***With respect to gross income earned from IP at a university or PRI, there is substantial variation across countries and even across PREs within a country*** (Table 29). In absolute terms US universities generated the largest amount of income from licenses, over USD 1.2 billion followed by Germany at EUR 6.6. million (PRIs only). Mean income per TTO is 7.7 million USD in US, EUR 2.8 million in Germany and only EUR 93000 in Japan. There is enormous diversity between different institutions. Indeed in 2002, Fraunhofer Society's license income amounted to EUR 19.6 millions, Max Planck Society's to EUR 17.7 millions and Helmholtz Association's to more than EUR 12 millions. An analysis of licensing income of these institutes is given in Figure 9. In Korea one institution reported earnings of over EUR 240 million. If this institution is omitted the average income for TTOs remains high but is more in line with other countries at EUR 232-258 million.
iv. Table 30 gives a measure of a TTOs' successful commercialization. It shows that ***"it is exceedingly rare for more than 50% of TTOs patents to be licensed. Indeed it would appear that somewhere between 20% and 40% of patents are licensed and only about half of these licenses – 10% of the patent portfolio – earn income"[110].***
v. Finally, to get an even better sense of the skewness of income generating patents and licenses, in the OECD survey TTOs were asked the number of their patents that accounted for 20% and 50% of their gross income from IP. Table 31 shows answers from the Dutch PREs as an example that could be obtained. "Half of the Dutch respondents claim that 20% of their gross IP income comes from two or fewer inventions. A quarter claim that just one invention counts for 50% of their total license income….. ***It is quite likely that not only do a small number of licenses account for a large part of a PRE's***

[108] Ibid., page 62-63.
[109] It is worth remembering that licenses generate income in different ways: some may ask for an up-front fee from the licensee, others for a percentage of royalties on sales, still others for a usage fee. Licenses can also use some combination of these mechanisms. Other income from IP includes income from cashed-in equity and payments under options and termination payments.
[110] OECD (2003), page 72. As noted in the report "there is a certain amount of variation across countries and types of PROs which needs to be confirmed through higher response rates and across more countries".

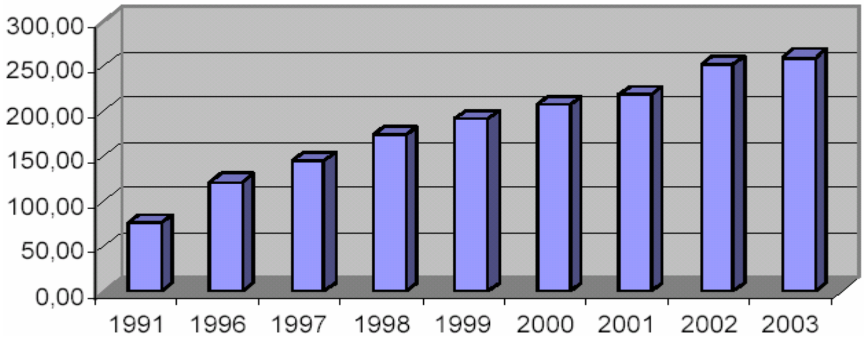
licensing income from IP, but also that a small number of PREs account for the majority of a country's total PRE licensing income"[111].

- Contract research revenues

Available evidence on contract research is limited and suggests that ***revenue of PREs from contracts with industry has been rising in some countries*** (***which may reflect the increase in the management efficiency of PREs and their TTOs), though the rise is not large and is uneven – evidence suggests a rise in countries that in the early 90s had weak traditions in Industry-Science Links (ISLs).*** Also, given that contract research and external research funding are linked to the quality and culture of the PRE's research base and its managerial and administrative capabilities, it is no surprise that it is usually very concentrated in a few PREs that have established strong connections with industry.

As shown in Figure 10 below in countries such as Spain with a weak tradition in ISLs the rise in contract research managed by University TTOs from 1991 to 2003 has been quite substantial[112]. However, the distribution is uneven. For example, in 2001, CSIC, the biggest Spanish research institution, received EUR 35 million in R&D contracts with business firms, or about 25% of the institution's total external funding – representing about 12% of total contract research funding in the country.

Figure 10: R&D contracts managed by university TTOs in Spain (Euro millions)



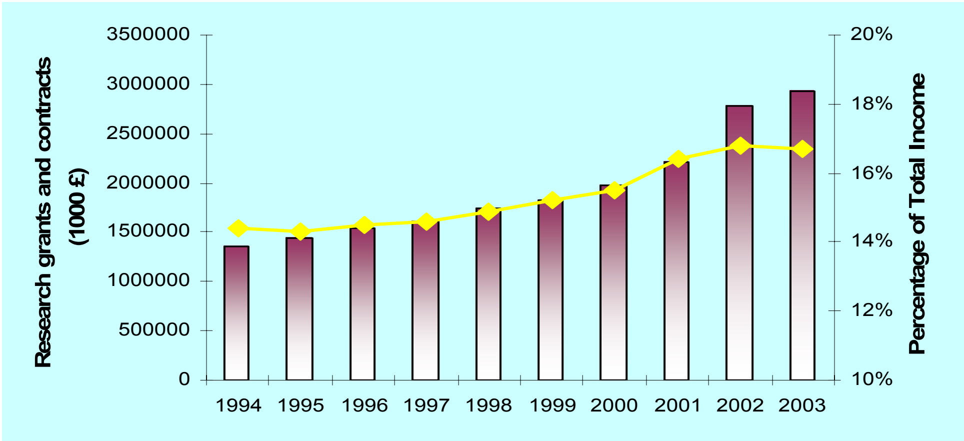
Source: Red OTRI Universidades (2002)

In other countries, such as UK, with a strong tradition in ISLs, as Figure 11 below shows, there has been an increase in contract research but this is limited–from about 14% of total income to about 16,5% of total income between 1994 and 2003 for HEIs.

[111] Ibid., pages 72-73. In US the average value of each license in 2000 was USD 150000, in Japan it was EUR 139000 and in EUR Switzerland (page 16).

[112] Garcia C.E & L.S. Menendez (2002), "From research to patents within Spanish PROs", CSIC Working paper 02-26.

Figure 11: Trends in Research Grants and Contracts of UK HEIs

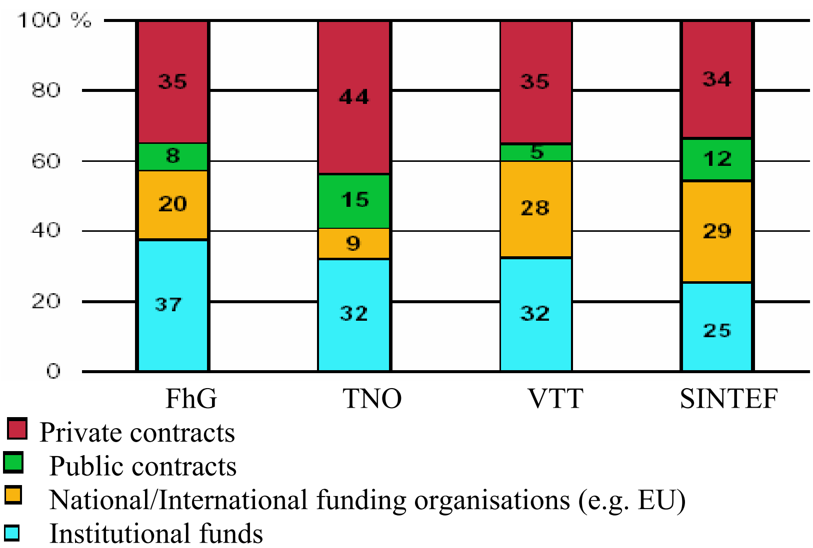


Source: HESA Statistics

As noted in Part I.B above, the proportion of industry financing of the research undertaken by PREs, is quite low standing in 2001 at 6,5% for the EU as a whole. It is worth comparing this to the contract research as a percentage of income of some of the top PRIs in Europe for which it has been possible to get available data.

We have already indicated that the figure stands at 25% for CSIC, the biggest Spanish research institution. On the other hand, in France, CNRS got only 7% of its total income from contract research from industry, though this represented about 75% of own-generated funds (from patents, services rendered and contract research), in 1999-2000. The Frauhnhofer Gelleschaft (FhG), the Netherlands Organization for Applied Scientific Research (TNO), the Norwegian Institute of Technology (SINTEF) and the Technical Research Centre of Finland (VTT) represent excellent examples of European PRIs with strong contract research records. Figure 12 shows the orientation of research of the above establishments as reflected in their financing structures. (Trends in contract research for the above PRIs are also presented in Appendix 4 to Part II).

Figure 12: Financing of contract research institutes in EU



Two points stand out clearly from the above: first, the share of industry financing of the research undertaken by these PRIs, at between 35% and 45%, is far higher than for public research in general in the EU (standing in 2001 at 6,5%). Second, however, this high proportion is not a recent phenomenon (see Appendix 4 to Part II, Figures I-III which show the high share of industry financing in dominant PRIs in earlier years).

The following Table (39) summarizes the results of the OECD (2003) survey on patenting and licensing activities of PREs.

Table 39: Summary results of the OECD (2003) survey on patenting and licensing activities

		Patents					Lícences			Slart-ups and spin-offs
		Total patent stock	Patent grants		Patent applications		Total number of active licences	Total number earning income	Gross income	Tolal number created in last year
			Number granted in last year	% Total stock	Number filed in last year	% total stock			EUR (000)	
Australia (2000)	All	-	498	- -	834	-	417	491	99 525	47
	Univ	-	219	-	586	-	234	-	79 834	32
	PRIs	-	279	-	248	-	183	.	19 691	15
Belgium (Flanders) (2001)	All	506	57	11.3	121	23.9	46	4	240	15
	Univ			-		-				-
	PRIs			-		-				-
Germany (2001)	All			-		-				-
	Univ					-				-
	PRIs	5404	747	13.8	1058	19.6	555	1188	66 368	37
Italy (2000)	All	-	64	-	190*	-	36*	84	-	36
	Univ	-	34	-	102*	-	27*	12	-	27
	PRIs	-	30	-	88*	-	9*	72	-	9
Japan (2000)	All	682	163	23.9	567	83.1	89	324	1397	6
	Univ									-
	PRIs									-
Korea (2001)	All	9391	1 018	10.8	1692	18.0	247	132	3822	56
	Univ	404	186	46.0	244	60.4	44	22	1032	19
	PRIs	8987	832	9.3	1448	16.1	203	110	2 790*	37
Netherlands (2000)	All	991	167	16.9	212	21.4	368	93	11 400	37
	Univ	394	64	16.2	111	28.2	250	.	-	27
	PRIs	597	103	17.3	101	16.9	118	-	-	10
Norway (2001)	All	-	-	-	-	-	-	-	-	67
	Univ	-	.	-	-	-	-	-	2 000.	16
	PRIs	114	28	24.6	43	37.7	22	39	7 700*	51
Spain (2001)	All	781	64	8.2	133	17.0	125	136	961	11
	Univ									
	PRIs									
Swítzerland (2001)	All	1 184	112	9.5	175	14.8	475	77	5650	68
	Univ	914	59	6.5	132	14.4	200	61	2800	56
	PRIs	270	53	19.6	43	15.9	275	16	2850	12
United States	All	.	5103	-	8294					-

(2000)										
	Univ	-	3617	-	6135	-	4049	8670	1 297 4 52	390
	PRIs	-	1486	-	2159	-	3007	484	69 600	-
Russia (2001)	All	-	349	-	171	-	206	8	1375	15
	Univ									-
	PRIs									-

Source: OECD (2003).

3.7 Conditions determining licensing and royalty generation

Although the empirical studies undertaken in the last few years which were reviewed in the previous sub-sections of this Chapter – foremost of which is the study by OECD (2003) – have shed new light in the previously largely unexplored area of the commercialisation activities of PREs in a number of the OECD countries, including at least some of the EU countries, US and Japan, the new information that is emerging has not been of sufficient magnitude and has not yet been subject to formal empirical econometric analysis, so that relatively safe and robust conclusions can be drawn regarding the conditions under which commercialisation will take one or the other form – e.g. licensing to other organisations rather than creating a spin-off – and/or for the success of commercialisation activities. Such analysis has, however, been appearing recently using US data and it is worth reporting here the main findings emerging.

Specifically, we refer to the study by Shane (2002) which also reviews previous papers in the area. As he notes empirical analysis to provide a systematic explanation of the type and profitability of university commercialisation activities is needed given that "researchers have recognised that *approximately half of university patents (in US) are never licensed*, and that licensing activity is not randomly distributed across patents"[113]. The OECD survey for example finds that in general, licensing to existing companies is preferred to licensing IP to a spin-off[114]. Shane uses for his analysis a population of 1397 patents assigned to MIT from 1980 to 1996[115]. A number of interesting findings emerge:

i. Inventions are more likely to be licensed by the university to other organisations "when patents are an effective mechanism for appropriating the returns to innovation because the patent system reduces the transaction costs of technology transfer"[116].
ii. University technology is more likely to be exploited through the creation of spin-off type companies (licensed back to inventors) when patents are not effective, as this "mitigates the adverse selection, moral hazard and hold-up problems that plague markets for knowledge"[117].
iii. When patents are effective, this "reduces the likelihood of license termination" and increases the likelihood that the new technology will be successfully commercialised – as a result, "the effectiveness of patents in a line of business

[113] He refers to the papers by Jensen and Thursby, 2001; Hsu and Bernstein, 1997; Barnes et.al. 1997.
[114] OECD (2003), page 16.
[115] He discusses at length the reasons why this specific data set is appropriate for the issues to be examined – pages 123-125.
[116] Shane (2002), page 133.
[117] Page 133. These are well known problems in the Economics of Information and are reviewed by the author too in pages 123-125.

increases the royalties earned from inventions licensed to (other organisations)”[118].

4. Public/Private Partnerships

In the EU MSs, a very large number of policy measures and support mechanisms for science-industry collaboration have, and are, been implemented. The diversity of these measures and schemes reflects the diversity in member states' infrastructure, research and innovation system, and political priorities. ***In general however, cooperation between firms and universities or research institutes is still not sufficiently developed in the majority of member states.*** This is a vast subject and the aim of **Appendix 3 to Part II** is to provide a comprehensive comparative examination of initiatives taken in order to enhance public private R&D partnerships in the European Union (EU), and in most MSs and to make comparisons to the USA and Japan which can assist one to understand the different environments for R&D collaboration.

As noted in AUTM (2002), the United States has been the first country that has stressed the potential value of close links between PREs (Universities and PRIs) and industry and gave priority to this in its policy – as we discussed above, the mechanism for technology transfer is found in the federal legislation known as the Bayh-Dole Act. By contrast, in EU, for a long time, a close interaction between PREs and industry has not been emphasized as an important element of the research and innovation system. Japan starting from a relatively weak policy context regarding the cooperation between the academic and industrial sectors have rapidly gained ground in the strengthening of public-private partneships during the nineteen's. During this decade it has enacted legislation (echoing the Bay Dole Act) that has helped substantially towards this direction.

The U.S. experience has clearly contributed to policy developments in Europe. However, as indicated by the AUTM (2002) report “although the technology transfer system developed in the United States has been viewed as a model, certainly, there are great differences between the EU and the United States. For example, the EU has not promulgated a regulation similar to the Bayh-Dole Act to foster interaction between academia and the business community”. However, at national level, some member states, recognising early enough the important role of Industry-Science Links (ISLs) in their innovation competence, launched similar kind of policies after a couple years of the Bayh-Dole establishment. This is especially the case of UK, which with LINK and the follow-up programmes, pioneered the field of governmental involvement and promotion of public/private R&D partnerships in Europe.

5. Concluding Remarks

- It has been argued that the European innovation gap is due to insufficient and inefficient scientific/technological transfer mechanisms. There have been a very significant number of policy initiatives in many EU countries in recent years that aim to change this through changes and amendments in the institutional, legal and regulatory framework facing PREs and, specifically,

[118] Ibid., page 134.

the ownership of IP and exploitation of research results created by PREs. It remains unclear which framework is preferable.

- In certain cases the institutional/regulatory framework restricts mobility between universities and industry (e.g. in Finland, Italy, Germany and Austria, where university professors and other employees have the status of civil servants, and are neither encouraged nor allowed to work temporarily within industry).
- Only 5 countries (Austria, Netherlands, Italy, Sweden, UK) report a change of status of PREs as comprising privatisation, in the period 1989–2001, covering an extremely small number (32 out of 705) of laboratories in all.
- Changes in the legal and regulatory framework have induced substantial growth in the establishment of TTOs in many countries in the last decade. Their structure differs in different countries and, again, it is not possible to identify an optimal structure independent of the country concerned. ***One of the main challenges facing PREs, despite the assistance provided by governments, is to attract and retain the human resources to manage TTOs and interact with scientists.***
- Creating professional patent and licensing agencies on a regional or sectoral basis (thus commercialising innovations for several universities) could strengthen commercialisation by PREs. Denmark, Germany and UK, are exploring this approach effectively[119].
- TTOs are involved in a broad range of IP and commercialisation activities. TTOs do far more than simply ensure the protection of patentable inventions. They are often involved in protecting and exploiting innovations in a number of technological fields[120].
- The overall picture that emerges is that in Europe – with the possible exception of UK and Germany – the patenting, licensing and commercialisation activities of Universities and other PRIs have not reached the size needed for having a significant impact on the R&D and innovation systems[121].
- The recent OECD survey (2003) concludes that ***"The long term viability of technology transfer operations remains an issue in most countries. However, evidence from successful TTOs suggests their positive influence as IP operations develop, and as they expand their operations beyond patenting and licensing to developing contract/sponsored research and providing technology consulting services, thus broadening their revenue base and generating more research for PREs".***
- Despite beliefs that firms prefer to license strong IPRs, it would appear that early-stage technologies (patent pending) and know-how are more frequently the object of licenses than stronger patents.
- Regarding TTO IP income, there is a great deal of variation among countries in terms of the average number of licenses per PRE that earn income and in

[119] OECD (2003), page 12. As the report notes a possible disadvantage of this approach is that it may lead to increased difficulty of developing close relations with employees of the PREs.
[120] Both the OECD (2003) survey responses and the recent DG ENTR (2004) report suggest this.
[121] Some responses to the OECD survey need clarification. The relation between the stocks of patents reported by TTOs and the flow of new patents granted seems skewed. While the number of patents granted is less than the total stock of patents under management, it seems large by comparison for most countries – expect Switzerland. There are many possible explanations. TTOs may not have good records of stocks. Alternatively, PROs may prefer to sell the rights to their patents outright or, if no buyers are found, they may allow patents to lapse, so that the number of patents owned by a PRE is in fact quite small.

the gross income generated. The median number of licenses per PRE that are active and earning-income, however, is relatively small in all countries, often between one and five. Differences in gross revenue, however, are large.

- ❖ While, it is too early to have a complete picture, it would appear across all countries that the percentage of active patents ever licensed is between 20% and 40% of the total, and that about half of these can be expected to earn income. Examining data on the concentration of income does not lead to definite conclusions, but indicate that a relatively small number of licenses earn a large proportion of the gross income at TTOs.
- ❖ International comparisons on technology transfer activities using data from the UK Universities and US institutions normalised to allow for valid comparisons, show that for the 2001-2003 period[122]: (i) UK universities create more spin-out companies compared to US institutions (ii) UK universities executed more licenses compared with US but had far fewer licenses yielding income, and earned less gross licence income than their US counterparts (iii) The UK performs less well than US in terms of number of invention disclosures and patents issued.
- ❖ PRIs seem to perform better than Universities in technology transfer activities in some countries.
- ❖ ***Non-IP related laws and regulations can be a barrier to technology transfer as well as fiscal rules that prevent PREs from receiving and retaining royalty income from licenses.***
- ❖ From the limited evidence available, revenue of PREs from contracts with industry has been rising in some countries though the rise is not large and is very uneven – the rise is significant in countries that in the early 90s had weak traditions in Industry-Science Links (ISLs). Also, ***contract research and external research funding is usually very concentrated in a few PREs that have established strong connections with industry.***
- ❖ Overall we can say that the European picture of significantly lagging behind US in terms of PRE commercialisation and exploitation is slowly changing, as PREs across Europe are adopting ways to more effectively ‘capture’ the benefits of public research and industrial collaboration. In addition, the Commission has been exploring ways to stimulate university commercialisation in the EU[123].
- ❖ There ***does not seem to be a substantially increased role of the business sector as a financier of research by PREs in the EU*** (since 1992), and even though some of the most prominent PRIs get a significant part of their revenue through private funding (about 40%) these are very few and, also, this is not a recent phenomenon.

---

[122] These results are reported in Appendix 1 of Part II.

[123] As part of this strategy it set up ANETTE (Academic Network for Technology Transfer in Europe) in 1991 to help universities across Europe share information and resources concerning the exploitation of university research. The network now has 11 members and is self-funding after four years of funding under the former SPRINT programme run by DGXIII/D of the European Commission.

PART III

Description and analysis of the public support to R&D measures of the Community's major trading partners

1. Introduction

The purpose of this Part is to outline the international regulatory environment concerning public support to R&D. This is an important source of information, since in the context of global competition, it informs about foreign effective schemes, which lie behind competitors' success and may be worth lobbying for/imitating. In addition it identifies the rules trying to establish a level playing field in international trade.

2. The international scene and the role of the WTO

The only international organization directly dealing with R&D support is the World Trade Organisation (WTO), in the context of its mission to liberalise trade. Neither the UN, nor the OECD or any other international organisation have a mandate on the topic. However, the role of OECD is relevant, even if in an indirect way, because in its recommendations for science, technology and industrial policy the spirit of the organisation refers to a regime conducive to innovation, which does not distort competition. In addition, the OECD has done substantial work in the past to collect detailed and internationally comparable data, undertaken with Ministerial Council guidelines for the OECD member states, to create a database on public support to industry (PSI database). Although the data was confidential and the database closed in 1998, important lessons were drawn and the current OECD MSTI-database is the only source, which can be used for systematic work in the topic at a broader geographical level.

However, the only concrete obligations for the EU and lessons to be learned come from the WTO, whose mission is to assure a level playing field among its members through the elimination of barriers to trade, including (among other support schemes) subsidies for R&D and innovation. The rationale for the WTO policy is very similar to the one of the EU and is based on mainstream knowledge of the distorting effects of subsidies to competition and trade. However, the organisation recognises the evidence of market failure and the need to consider certain types of aid as stimulating rather than hampering international growth and optimal resource allocation. Trade Distortion is the principle, the rationale on which different types of subsidies are "categorized" under the Agreement on Subsidies and Countervailing Duties (SCMA), which deals with subsidies and countervailing measures: penalizing duties imposed against damaging subsidies of another state (Sauvé, P. 2002).

In the WTO there ***was*** a special regime for R&D (falling with other measures under the category "non-specific" in the WTO jargon, which corresponds to "horizontal" in the EU jargon) determined by Art. 8 (Identification of non-actionable subsidies) of the SCM Agreement[124], which foresaw a temporary exemption to certain categories. This has expired and the unified procedure is now as follows:

Step 1: Notification by the members: WTO members notify subsidies once a year (Members are currently required to present new and full notifications every two years, and updates every year). Although the obligation is to notify only specific aid, the WTO encourages its members to notify any subsidies deemed to be specific. The

[124] WTO, Subsidies and Countervailing Measures Agreement , Articles 5, 6, 7 and 8.

notification does not prejudge the legal status or the nature of the measure. Unlike the EU procedure the notification serves only transparency and measures enter into force when the respective country considers it appropriate, without any prior agreement or control.

Step 2: Transparency procedure: The notifications are discussed in the SCMA Committee with the rationale of informing all members and giving them the opportunity to ask for clarifications. A counter-notification procedure is foreseen: if a country fails to notify a scheme, any Member has the right to ask questions, which the alleged notifying Member has to answer immediately. Empirically it appears that for many disputes the case starts to mount in this Committee.

Step 3: Dispute settlement procedure: If a country considers that there is a subsidy, which causes adverse effects in the sense of Article 5 of the SCM Agreement, it initiates a dispute settlement procedure and the burden of the proof lies on the complaining country.

R&D grants have never been a problem in the transparency procedure and have only been included in one case of dispute settlement (Canada and Brazil aircraft industry). The Boeing-Airbus case, which includes elements of R&D subsidies as well, may be the next but as things look at the moment it is not clear how it will be treated in the end. This does not preclude that there will not be such dispute settlements in the future, in particular as China and India are rapidly entering the international competition arena.

As the WTO regime is less strict than the EU rules European companies sometime request an initiative from the EU to modify the rules reinforce the WTO procedure by giving the organisation the means to really assure a level playing field at the international level (EICTA 2000).

Briefly in conclusion, evidence from the WTO suggests that:

- R&D subsidies constitute a special case hardly ever occupying the organisation; the emphasis lies in export subsidies;
- the organisation applies similar principles to those of the EU, but monitoring procedures and enforcement rules are quite different;
- the R&D notification procedure and monitoring offer some interesting information but does not assure a level playing field;
- the monitoring procedure offers interesting features but because of the limited power of control and enforcement by the WTO, it does not appear very effective.

3. Evidence from the main competitors

3.1 The broad picture: Aggregate public support to industry

The share of business R&D directly supported by the public budget varies considerably from country to country. Studying the various types of public support for industrial technology the following interesting patterns emerge[125]:

[125] Evidence from OECD (2004), Science, Technology and Industry Outlook and Young (2002)

- Japan offers over 50% of total support for industrial technology in terms of S&T infrastructure, direct financial support in terms of grants is marginal but considerable amounts of government contracts are given to the business sector following a development rather than procurement logic.
- The US demonstrates an incredibly high share of defence, space and similar contracts (69%), with federal grants representing 16% of the total. While these figures are elaborated for 1996 (there is nothing more resent processed) there are good arguments why the composition, if shifted, then it is at the cost of direct funding: on the one hand recent evidence suggest reduction of direct funding (OECD Outlook 2004) and on the other there are no broad new federal schemes for direct funding, whereas funding for university-industry cooperation is increasing (See Part II).
- Direct funding is applied mainly by Canada and to a lesser extent Australia, where direct contracts are lower, while in the EU itself figures vary considerably.
- In the EU the supranational research funding (EU budget) constitutes less that 5% of the overall support in the territory, which in all the major competitors the inverse is true: federal/national budgets account for 85-95% in the US, Canada, Japan, Korea and Australia. This differentiates strongly governance and regulatory needs.

The last comparable data elaborated by the OECD suggests a rapid fall in the share of R&D in the business enterprise sector financed by government in the United States and in the European Union, while there was a slight rise in Japan due to a very low initial level. In all three cases, the trends in the percentages reflect changes in the level of government-funded BERD at fixed prices (OECD Outlook 2004).

The rules for public intervention depend on the type of governance in each country, as well as on the informal rules governing policy design, hence the unique European governance, differentiates the Union strongly from its competitors.

In the US R&D support is mainly a responsibility of the central government, which accounts for more than 90% of total direct support to industry. The state level only emerged as a source of industrial research funding in the '90s and until now it remains marginal. ***Whether of inertia or conviction the rules are set at the federal level, and states are practically free to operate their support mechanisms in the way they consider appropriate as long as they comply with competition policy*** (firm level considerations). However, the perception of a liberal economy and the support given by the efficient use of venture capital have resulted in a tradition of public support not exceeding 50%, with the exception of the case of public procurement indicated below.

Similarly in Japan and Korea the key actor is the central government, which can play a role that ranges from strongly interventionist and political (as the MITI-keiretsu relationship in previous decades and the current dialogue between the government and chaebols in Korea) to centrally funded industrial incentives. The role of the regional level in these countries is more a role of implementation of centrally decided schemes. R&D aid in Taiwan and Malaysia, both being smaller countries, is designed and implemented at the central level.

Identifying specific schemes in the main EU competitors is both an easy and a difficult task: Finding out which are the most popular and long lasting schemes is easy through publications and web search. However, going into details on ceilings and type of criteria becomes more difficult and almost impossible in classified areas like defence procurement (which is a case of major interest in the US). An additional difficulty arises for the Asian schemes, which are mostly published in national languages. Finally one should note that in all competing countries there are indirect schemes of tax credits, which have been studied in detail in other documents and are not the focus of the present study (European Commission 2001, Innovation Paper No 19).

3.2 Lessons from the US

The characteristics of the US are that:

- public support for industrial technology is mainly financed at the federal level
- most recent evidence suggests that the federal support is composed by 85% grants and 15% tax credits
- federal support for industrial technology was almost all paid to firms, with the largest share in the form of mission-oriented contracts and procurement (Young 2002)
- there is no specific set of state or even federal rules for public support to R&D (Verhaar 2003). Competition policy (in the form of anti-trust) is the only regulation, while a deeply-rooted conviction for a limited role of the public sector in the market has resulted in all schemes limiting the ceilings.

In terms of schemes and legislation at the federal level, as of the early 1980's, a set of US Federal S&T policies facilitated private R&D funding, cooperation and technology transfer. More specifically, the latter consist of the following[126]:

1. The 1980 **Stevenson-Wydler Technology Innovation Act** which required Federal laboratories to assist the transfer of federally owned and originated technology to state and local governments and the private sector. The 1986 *Federal Technology Transfer Act* modified the Stevenson-Wydler Technology Innovation Act to permit cooperative research and development agreements (CRADAs) between Federal laboratories and other bodies (state agencies being included). Also, the 1989 *National Competitiveness Technology Transfer Act* amended the *Stevenson-Wydler Act* to allow government-owned, contractor-operated laboratories to enter into CRADAs.
2. The 1980 **Bayh-Dole University and Small Business Patent Act,** which allowed government grantees and contractors to maintain title to federally funded inventions and encouraged universities to license inventions to industry. The act was designed to promote interactions between academia and the business community.
3. The 1982 **Small Business Innovation Development Act,** which established the Small Business Innovation Research (SBIR) program within the main Federal

[126] NSF, Science and Engineering Indicators, Chapter 4, US International Research and Development, Funds and Technology Linkages, 2004

R&D agencies to rise government funding of research that has commercialisation prospective within small high-technology companies.

4. The 1984 **National Cooperative Research Act,** which encouraged U.S. firms to collaborate on generic, pre-competitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures. The act was amended in 1993 by the *National Cooperative Research and Production Act* (NCRPA), which let companies collaborate on production activities as well as research activities.
5. The 1988 **Omnibus Trade and Competitiveness Act,** which established the Competitiveness Policy Council to develop recommendations for national strategies and specific policies to improve industrial competitiveness. The act created the Advanced Technology Program and the Manufacturing Technology Centers within the National Institute for Standards and Technology to help U.S. companies become more competitive.
6. The 1993 **National Cooperative Research and Production Act,** which eased restrictions on cooperative production activities, make possible for research joint venture participants to work together in the application of technologies they jointly get hold of.
7. Finally, the 2000 **Technology Transfer Commercialisation Act,** which modified the *Stevenson-Wydler Act* and the *Bayh-Dole Act* to improve the power of government agencies to monitor and license federally owned inventions.

Programmes from which industry benefits (or can benefit) alone are mainly the Advanced Technology Programme and the SBIR, described in the two boxes hereafter:

BOX A. Advanced Technology Programme (ATP)

Scope

The Advanced Technology Program (ATP) operated by the National Institute of Standards and Technology, “bridges the gap between research labs and the market place, stimulating prosperity through innovation”. Through risk sharing the ATP focuses on projects with a high payoff for the nation as a whole - adding up to a direct return to innovators.

Some critical features

- ATP projects focus on the technology needs of American industry, not those of government. Research priorities for ATP are set by industry, based on their understanding of the marketplace and research opportunities. For-profit companies conceive, propose, co-fund, and execute ATP projects and programs in partnerships with academia, independent research organizations and federal labs.
- ATP has strict cost-sharing rules. Joint Ventures (two or more companies working together) must pay at least half of the project costs. Large, Fortune-500 companies participating as a single firm must pay at least 60 percent of total project costs. Small and medium-sized companies working on single firm ATP projects must pay a minimum of all indirect costs associated with the project.
- ATP does not fund product development, marketing, sales and distribution.
- ATP awards are made strictly on the basis of rigorous peer-reviewed competitions. Selection is based on the innovation, the technical risk, potential economic benefits to the nation and the strength of the commercialization plan of the project.

- ATP's support does not become a perpetual subsidy or entitlement - each project has goals, specific funding allocations, and completion dates established at the outset. Projects are monitored and can be terminated for cause before completion.

Beneficiaries

ATP partners with companies of all sizes, universities and non-profit organisations.

Implementation

More than half of ATP awards have gone to individual small businesses or to joint ventures led by a small business. Out of 768 ATP projects selected since its inception, well over half of the projects include one or more universities as either subcontractors or joint-venture members. The amount spent in 2002 was $184.5 million. *It may be of interest to not that on the site of the Institute it is announced that there will be no call in 2005.*

Eligibility and evaluation procedure

All industries and all fields of science and technology are eligible. Proposals are evaluated by one of several technology-specific boards that are staffed with experts in fields, such as biotechnology, photonics, chemistry, manufacturing, information technology, or materials. Transparency rules are respected and support for applications is offered.

Impact assessment

A number of evaluations and impact assessment studies identify the following key influences:

- More than half of the projects would not have been undertaken in the absence of ATP support (while the remaining projects would have taken longer to complete, would have been less technically challenging and would have generated fewer technical outputs)
- Speeding up the development and commercialization of new technologies
- A "halo effect", as ATP awards establish or add to their expected value ("prestige") in the eyes of would-be investors,
- Over 3 out of 10 reporting projects leveraged other sources of funding,

Sources:
http://www.atp.nist.gov/atp/overview.htm,
Link, A., Scott, J., *Evaluation of ATP's Intramural Research Awards Program*, prepared for Economic Assessment Office, Advanced Technology Program, National Institute of Standards and Technology, December 2004,
National Institute of Standards and Technology (NIST), *Measuring ATP impact : 2004 Report on Economic Progress*, NIST, 2004,
Wessner, Charles W., *Innovation Award Programs in the US*, presentation at Policies and Programs to Build Entrepreneurship, December 15, 2003.

BOX B. Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs

Scope

The Small Business Innovation Research (SBIR) program (operating since 1982) is a "set-aside" program for domestic small business to engage in Research/Research and Development that has the potential for commercialization. Federal agencies with extramural research and development budgets over $100 million are required to administer SBIR programs using an annual set-aside of 2.5% for small companies to conduct innovative research or research and development (R/R&D) that has potential for commercialization and public benefit. To date, over $12 billion has been awarded by the SBIR program to various small businesses. The Small Business Technology Transfer Act of 1992 established the STTR program. Federal agencies with extramural R&D budgets over $1 billion are required to administer STTR programs using an annual set-aside of 0.30%. Both programmes are periodically evaluated and are re-launched with Congress approval.

Critical features

The ***objective*** is to stimulate technological innovation, strengthen the role of small business in meeting Federal R/R&D needs, increase private sector commercialization of innovations developed through Federal SBIR R&D, increase small business participation in Federal R/R&D, and foster and encourage participation by socially and economically disadvantaged small business concerns and women-owned business concerns in the SBIR program.

Funding rules: The programme funds projects with lump sums, notably for *Phase I.* (technical merit and feasibility) for six months/$100,000 for SBIR and one year/$100,000 for STTR and *Phase II.* (continuation of the R/R&D efforts) up to $750,000 total. However, applicants may propose longer periods of time and greater amounts of funds necessary for completion of the project. ***Deviations from the indicated Phase I/Phase II statutory award amount and project period guidelines are acceptable but depend on the rules of and agreement with the funding agency.*** *Phase III.* may involve follow-on non-SBIR/STTR funded R&D or production contracts for products, processes or services intended for use by the U.S. Government.

The SBIR & STIR programme offer an interesting basis for discussion in the sense that it does not follow the general rules of a fixed budget and specific ceilings, but offer lump sums in the first phases, which may be any share of the total cost of the project.

Impact assessment

SBIR impact has been examined through its role in university-industry cooperation, its attraction to entrepreneurs and policymakers and its contribution to the overall innovation policies. Regarding SBIR's role in university-industry cooperation key benefits are based on the fact that

- SBIR Innovation awards come up with a direct impact on the creation of new firms (thus contributing to regional growth and the creation of jobs, and, more specifically to the creation of high tech jobs),
- Universities help to diversify and grow the job base, and
- Cooperation gives value to research funding, not only because of the returns to society in "health, wealth and taxes", but in addition because SBIR funding verifies positive expectations within an "uncertain game".

As for entrepreneurs SBIR grants are attractive not only for cost-funding reasons but also because there are no royalties owed to the government, they retain intellectual property rights developed by SBIR funds, whilst a "certification effect" exists. As for policymakers, SBIR is a catalyst for new ideas and technologies, it capitalizes on substantial R&D investments, it addresses gaps in early-stage funding for promising technologies, at the same time as they are attractive to small firms and serve as certification of technical quality. As for SBIR contribution to overall innovation policies this is based on the fact that it provides a small companies-agencies link, a university-market place link, it encourages local and regional growth, whilst contributing to new methods and technologies.

Finally, an additional outcome suggests that SBIR builds innovation capacity in states where it is already relatively well developed, meaning a greater contribution to overall global competitiveness of US manufacturing, instead of a (spatial) dispersion of effects.

Sources:
Patterson, F., *Regaining Ground. Business Development and the SBIR Program in Texas*, Texas Business Review, April 2004.
Van der Vlist, A., Gerking, S., Folmer, H., *What Determines the Success of States in Attracting SBIR Awards*, Economic Development Quarterly, Vol. 18, No 1, February 2004, p. 81-90.
Wessner, Charles W., Innovation *Award Programs in the US*, presentation at Policies and Programs to Build Entrepreneurship, December 15, 2003.

Mission oriented research is the most important lesson to learn from the US, but information in that respect is indirect, as most of this work is classified. More important that the direct subsidies in the US are the NASA and the defence industry support mechanisms, using a triple argumentation of defence benefits, infant industry and externalities. *Homeland security will probably be added in the list now*.

Except for the Department of Defence and NASA the Clinton Administration, which has been very much supporting government involvement in end-assistance to commercial high technology initiatives has funded a numerous commercial R&D initiatives including: (George Kleinfeld and David Kaye, 1998)

- "The government-industry consortium, SEMATECH, to improve semiconductor manufacturing technology
- The technology re-investment programme, developing commercial applications for defence technologies
- The high performance computing and communications programme, an inter-agency coordinating mechanism for computer R&D established in 1991
- The partnership for new generation vehicles (PNGV) a government partnership with the big three US automakers to develop technologies that improve fuel efficiency and emissions control
- The flat panel display initiative, a defence department effort to develop a domestic flat panel display industry that would support approximately 15% of the world market".

Information on R&D support at the state level is presented in the Appendix to Part III. State aid is low and mostly channelled through universities and R&D centres, with a tendency to have matching partnerships with companies rather than direct subsidies. Besides, funding at the state level is far too low to be of real concern for distortion. Relatively few states accounted for a large share of total state R&D support in the Nation. Only five states -Texas, California, New York, Florida, and Pennsylvania- reported more than $200 million in R&D and R&D plant expenditures. Combined, those five represented 44 percent of the total reported for all 50 states. By comparison, for many smaller states in which state government R&D spending was considerably less, the levels nonetheless represented a substantial investment relative to the state's population size—led by Kansas and Hawaii. Also, although no state reported that R&D activities accounted for a large share of total state spending, those with the highest R&D-to-total spending ratios were relatively small states. Only Nebraska, Kansas and Georgia indicated that spending on R&D and supporting facilities accounted for more than one percent of state spending for all purposes.

In terms of procedure federal R&D support follows two distinct routes, depending on whether it is getting budget appropriations for programme renewal or an approval and launch of new programmes.

Budget appropriations for renewals

The continuity or not of a programme depends on the agreement of the Office of management and Budget (OMB), which controls not only formally but also in terms of content the proposals made by different agencies. The procedure used for that is: For each programme requesting a budget the agency responsible has to fill in a self-evaluation Programme assessment Rating Tool (PART), which assesses the purpose, planning, management, and accountability of individual government agencies. Based on an agency's response to the PART questionnaire, OMB evaluators grade its programs as "effective," "moderately effective," "adequate," "ineffective," or "results not demonstrated." "Results not demonstrated" indicates that are no objective criteria in place to measure the program's effectiveness; a failing that the PART evaluation process seeks to remedy. The OMB reserves the right to accept or modify the self-assessment of the agency. Hence the budget is based on past performance.

Agencies of the executive branch must also be responsive to the Government Performance and Results Act of 1993 that requires agencies to produce strategic plans and long term goals and objectives, with annual plans that specify measurable goals to be achieved and annual performance reports that compare actual results to original goals.

In addition, President Bush issued the President's Management Agenda in his first term which entails five government-wide initiatives, including budget and performance integration that requires agencies to focus greater attention on performance and integrate performance reviews with budget decisions. The first performance budget was submitted for FY 2004. It is expected that information on performance of programs will be used to continue funding, reform, or terminate programs and activities. The annual budget cycle begins with the president's budget that is generally submitted by the first Monday in February which is not binding and is considered to be a proposal and request. Justifications for renewal of funding must be submitted to the heads of the respective agencies and then later submitted to OMB well before the president submits his budget to Congress which will then develop their own budgets for discretionary programs (which R&D programs fall under), knowing that these bills must pass both houses of Congress for the president's signature or veto.

New programmes

When the need for a new programme arises it is presidential staff or congressional staff who identify the need and ask for expert advice by competent agencies to form such a programme (agencies can use experts, rely on academic evidence, organize workshops etc). Based on the reports created there is a debate and the programme is voted or not (the usual procedure of presidential veto applies) and if accepted a program is authorized by statute and a new bill is created. Based on this debate Congress appoints the agency responsible, which rules how to implement the programme without going back to congress. The authorizing legislation stipulates the responsible agency for the new programme. The agency is then tasked with writing the Rule to implement the statute. Funding still must be given by the requisite Congressional appropriations committee for the program to operate.

Hence, unlike the EU, in the US there are not general rules on precise limits as to which categories are funded, how additionality/impact are measured or what are the ceilings of support. Tailor made assessments and expert advice offer a certain degree of flexibility, within the general principles for R&D policy.

3.3 Specific lessons from other countries

A: Japan

There are no general public aid rules in Japan (Verhaar 2003). The success and the transformation of the Japanese economy have been attributed to the partnerships between the government and the industrial conglomerates (keiretsu), although these relationships are now rapidly changing. As Japan's industries achieved world class status in the 1980s, government policy began to shift toward a focus on the earlier phases of R&D. This change toward objectives similar to the U.S. and European programs resulted from the realization that Japanese companies needed to prepare for subsequent technology life cycles in advance rather than. Japan has established several R&D programmes since the 1980s aimed at basic and fundamental R&D in response to the criticism of its free-riding on Western basic research. In some of these programmes, the linkages between university, industry and government have been a requirement for formation or selection of projects. Appraisals show the significance of the partnership and shows that the projects of the Next Generation Programme for pre-competitive research formed few but multiple university -industry- government linkages within each project by designing the complementary relationships among the participants.

B: Korea

In terms of tax incentives Korea is a generous incentive providers -defined by B-indexes of less than 0.9 for small companies and a moderate incentive provider for all companies -defined by B- indexes greater than 0.9 and less than 1.0 (Warda), follows very much the Japanese partnership principle, and declares to the WTO a broad range of mission oriented research. Both in this and the generous R&D support for inward investing companies Korea at the national level gives a very favourable treatment to local and foreign companies. NO details about ceilings are given.

C: Canada

The federal government uses contract research, grants and contributions to support industry. An interesting case is the Technology Partnerships Canada (TPC, http://tpc-ptc.ic.gc.ca/epic/internet/intpc-ptc.nsf/en/Home), a special operating agency of Industry Canada with a mandate to provide funding support for strategic research and development, and demonstration projects that will produce economic, social and environmental benefits to Canadians. TPC's main R&D program is geared to pre-competitive projects across a wide spectrum of technological development. The program focuses on key technology areas such as Environmental Technologies, Aerospace and Defence Technologies and Enabling Technologies, which includes biotechnology and health related applications, as well as manufacturing and communications technologies.

TPC has partnered with the National Research Council (NRC) to provide pre-competitive or pre-commercialization assistance to small and medium-sized enterprises (SMEs) through NRC's Industrial Research Assistance Program's (IRAP) national network of Investment Technology Advisors. Eligible costs of the project should not exceed $3,000,000. Special procedures are foreseen for higher amounts. Like in the US the ceilings are a result of the country culture rather than a general regulatory barrier.

4. Summing up the evidence gathered

The key conclusions from the research on the WTO procedures and the R&D support policies and schemes in the major competitors of the EU are summarised below[127]:

1. The most important conclusion is that when comparing the EU regulation on R&D State aid with corresponding instruments of its main competitors ***it is a comparison of different structures;*** only in EU is State aid subject to formal trade distortion controls, in all major competitors central authorities do not formally prescribe such regulation.
2. This institutional difference is almost self-evident, since ***in all other cases the federal/central budget plays the dominant role*** and contributes more than 85-95% of the total public funding. Thus any regulation with serious effects would have to be self-regulation, rather than a central authority controlling a lower level of governance. However, despite the lack of regulation only in exceptional cases and in mission-oriented research are threshold of 50% overtaken.
3. The WTO follows the same philosophy with the EU, controlling State aid for trade distortion, but ***the major dissimilarity between them consists in their very different margins of enforcement***. Given its limited power the WTO plays a role of moderate transparency rather than assuring a level playing field among its members. However some of its procedures may offer interesting ideas for an improvement of the EU system.
4. In terms of trends it is important to note that (with the exception of Japan, which has a very low share anyway) ***direct government support to business R&D has declined both in absolute terms and as a share of business R&D in the OECD***. Indirect schemes, like tax incentives, the stimulation of entrepreneurship, venture capital and public private partnerships, with special emphasis in university-industry cooperation, are becoming more important.
5. The main lesson from the US is that the structure and philosophy of R&D State aid differ considerably: direct industry funding is more limited than in

[127] These conclusions only partly coincide with recommendations from the UNICE, EIRTA and IRDAC. It is also interesting to compare them with the conclusions of the only similar paper found (Verhaar 2003), a summary of which appear in the Appendix to Part III.

the EU and it is mainly composed of federal funds; state funding is very low but increasing and it is regulated at the state level only. The interesting part of ***the US lesson is that, there are some very efficient and generous instruments, which are not direct but they assure important funding for particular categories of projects and companies***. Both bigger companies, in the form of mission-oriented research and for smaller ones in the form of SBIR can benefit from them. These are support instruments over and above ATPs, the regular business R&D support instrument.

6. Direct funding in Japan is very limited but mission oriented networks are highly exploited, while individual cases in Canada and Korea indicate that since there are no general rules, when considered necessary or strategic, governments can offer attractive support packages. ***In case it is judged necessary all these countries seem to have the legal possibility to tailor schemes to industrial needs.*** While similar considerations are possible in the EU their implementation has to go through a procedure which may be perceived as cumbersome and may discourage national governments or individual companies
7. Because of these fundamental differences between central and state level competence and share, competing countries do not need to apply strict and general rules, when designing R&D support schemes. Each broader programme is agreed at central level, debated (in government or Congress), approved and then executed through peer review. Thus criteria are applied for projects rather than for programmes. The stages to be adopted are defined in the programme itself and no additionality tests are required ex ante. Ex post the different studies and evaluations in the US are trying to assess additionality (or crowding out), mainly using data from surveys responding to the question whether the projects would have taken place without support.

The overall result of the conclusions from non-European experiences is that in the EU the combination of the low share of supranational R&D funding (FP being less than 2% of total European GERD) with the strict rules for the non discriminatory effects of State aid, seriously limit the degrees of freedom for an effective and, when necessary, selective European R&D policy. This applies both to funding and time dimensions. In terms of effectiveness the differences with the main trading partners is that for them innovation and closer to market support seems to be more acceptable through the eminent role of mission-oriented research, than it is the case in Europe.

While this is a significant difference there is only limited corrective action that can be taken. The European governance system sets the boundaries and radical solutions would request either a revision of the WTO, to assure mandatory practices of level playing field in all WTO members, or a revision of the EU Treaty, to relax European procedures. Both are politically sensitive, unlikely to be worth opening at that stage and might open up more problems than they resolve, so there is no point of raising either one of these issues at that stage. Given the limited degrees of freedom the direction of R&D policy could take the following could minimise the disadvantages:

1. Find ways to fund activities of particular interest (mission orientation) from an increasing EU budget and grant more often derogations for important projects of common European interest. This goes very much along the line of the UNICE positions, as well as of the new tendencies for technology platforms.

Studies to activate public procurement policies in the national level, by creating new rules for technology procurement are also under way in Europe.

2. Relax at least the procedure of granting State aid, to avoid adding a time and bureaucracy constraint to the actual ones. Suggestions for that are offered borrowing from the experience of the WTO hereafter. Mission orientation, public-private partnerships, mega-clusters and networks, special treatment of small dynamic companies at the member-sate level need a more generous approach.
3. Work in the context of the OECD towards the establishment of a better statistical coverage, transparency and information of what is the actual Central/Federal and State/Regional aid in its competing countries, since with the present state information in the Triad end up by being asymmetric.
4. Investigate alternative regimes using simplified procedures based on notification and transparency, which could be easier and faster to handle.

PART IV

Description and analysis on the basis of the categories of research activities

1. Introduction

The objective of Part IV is to discuss the nature of R&D, alternative definitions and potential taxonomies, as well as the interaction between R&D and innovation. Judging on the appropriateness of these definitions one can conclude with suggestions on the extent to which they are tolerable, wishful or create distortions and see how the different stages are separable and identifiable by alternative control mechanisms.

The world and our knowledge on science and technology policy as well as innovation are changing rapidly. The linear model, which permitted easy conceptualisations and implied simple subsidy rules was abandoned and replaced with the chain-link model, which stresses the complexity and interaction between research phases as well as between research and innovation. Actors, who used to be a good way to distinguish activities, are also changing roles: in earlier years universities were undertaking basic research and to a lesser extent applied research, companies were taking over from applied research through experimental development to innovation. More and more leading companies undertake basic research, more and more universities shift to activities closer to the market.

2. Definitions, concepts and further discussions

The categories *"fundamental, industrial research, pre-competitive development"* as defined in *"Annex I of the R&D aid framework"* reflect a traditional way of thinking and have the advantage of being (supposedly) easy to recognise and in compliance with the standard international manuals. These categories, presented on Appendix 1 of Part IV, are based on attempts of international organisations to standardise definitions for purposes of interoperability and the creations of comparative statistical evidence.

However, all evidence of science policy research converges to the conclusions that this distinction is a lot more difficult to apply in the real world than on paper, and, what is even more problematic and confusing, is that the various phases are not undertaken in a sequential way but interact constantly. Thus ***most research projects in the real world are composed of elements of all categories of research***. This means that any research project is likely to be composed of all stages of research and even more, ***it is only with hindsight that one knows what type of research and in what mix was necessary to achieve a specific target.*** In many cases the boundaries between R&D and innovation are less clear than in the prescriptions of the manuals.

2.1 The academic debate: research phases and the justification of public support

Academic research is using the statistics based on the standard definitions, but express often doubts as to the ability of the categories to be used as explanatory variables of the growth process. The first radical criticism to the standard definitions and the linear model is attributed to the introduction of the "chain-link" model, which explains the systematic interaction of the various phases. Economists often use more diversified categories, because they recognise that for analytical purposes the standard definitions are too restrictive, so they try to expand them to be closer related to real world activities[128]. We hereafter try to indicate the restrictions of the standard definitions and their inability to explain reality.

A first problem is that ***these types of research are not implemented in a linear or any other type of systematic order***, as indicated above. Interactive models are now dominating current thinking, where stages interact and feedbacks are constantly necessary to achieve a specific output. Besides, the concept of basic research is broad and includes two different types of activities, namely:

- "*Blue sky research*", which investigates topics of unknown economic relevance and potentially high scientific value; hence results of this type of research may prove highly important or totally irrelevant for production and competitiveness; as a consequence this type of research is practically only funded and executed in HEIs and public research laboratories;
- "*Mission-oriented basic research*", which is linked to the lack of knowledge for better understanding/shaping and improving production; this is the reason multinational corporations have 2-3 decades ago started investing in this type of basic research. In sectors like the aerospace industry and in disruptive technologies mission-oriented basic research is highly relevant for the continuation of technological trajectories.

An additional problem, if trying to apply so complicated concepts going beyond the simple distinction between 'fundamental/applied/development' is that both inputs and outputs in the research process are highly intangible and often not measurable. Proxies are people, hours, payrolls, research papers, patent applications and grants, memoranda, blueprints, new plants, products and processes, ***but the problem for assessing and identifying types of research is that all of measures/proxies, separately or together do not capture the whole spectrum of intangible inputs and outputs of the research process.*** As a consequence it is not possible to use measures for a very clear distinction of research phases.

In the core of the academic debate lie two major concepts that can be used for assessing the effects on competition: uncertainty and appropriability.

Uncertainty is related to the relatively high failure rate of research projects. When deciding on a project from a certain portfolio of potential projects and technologies, companies are well aware of a high rate of projects that will end up by increasing their knowledge but with non-specific results. Research has a positive impact on the firm investment on human capital but not directly on return on the investment. Thus, with hindsight one may argue that projects which fail are unlikely to distort competition and in that sense they could be supported. The problem is again that this can only be known ex post, and once this knowledge is available it is too late to use it for policy purposes. Yet, if this argument is correct, then one can suggest that the public support tolerated without distorting competition should be a function of the uncertainty of a

[128] For instance in their work on "The economics of Industrial Innovation" Freeman and Soete (1997) distinguish the stages of research, invention, development and innovation as follows:

1. Basic research (intended output: formulas)
2. Inventive work (including minor improvements but excluding further development of inventions, intended output: sketches)
3. Development work (intended output: blueprints and specifications)

New type plant construction (intended output: new plant and new products).

project. Subsidies should follow a rule of average uncertainty (a measurable risk) and be applied accordingly. This is to a large extent happening with *one major assumption, namely that the closer a product to the market, the lower its risk*. A second major assumption of this kind is that *the longer the time horizon the higher the risk of a project* because external conditions are more likely to change compared to initial assumptions. It is suggested however that ***the idea of a clear relationship between time to market and risk/uncertainty cannot be taken for granted***. There are two reasons this assumption of diminishing risks as one comes closer to the market, faces two major challenges:

1. There are important sectoral differences, which need to be addressed. The risk in fundamental research in one sector is not necessarily the same as in another one. Thus sectoral differences should be taken into consideration, although this constitutes an additional refinement that may make policies too detailed.
2. The complexity and interaction of different stages in modern research indicates a mixed risk and research projects closer to the market do not always carry a lower risk.

Ideally the design of subsidies should then be based to an estimated risk factor, the higher the risk the higher the support rate. As shown in later sections companies do take this consideration into account in their internal assessment of selection of R&D projects. From a policy perspective though it is very difficult to assign risk factors; but one can borrow instruments from risk analysis to bring this argument forward.

Appropriability is another concept that affects the justification of support for various types of research. The basic rationale is that the more the research results are appropriable the lower their diffusion, thus limited externalities and limited social returns on investment. This leads to the suggestion that ***highly appropriable research results will distort competition and should not be supported***. There are again two problems with that:

1. The driver behind private research are the monopolistic returns of intellectual property rights. Companies will not invest in research, not even if they are subsidised, unless they expect above average rents.
2. As with risk so with appropriability one never knows ex ante how diffusion patterns of new research results will work out. Research results may diffuse rapidly and increase overall productivity through licensing, in highly appropriable cases, or may not be worthwhile the investment and not diffuse even if weakly protected. More than that, diffusion may occur through the advancement of the state of the art, without diffusion of specific methods or artefacts.

There is one additional methodological remark when dealing with the impact of research results on overall welfare: the impact of research may be positive but it would occur anyway, with or without subsidy. Using public funds to support research that would have been undertaken anyway is known as a "crowding out" effect. In order to avoid that public policy is geared towards supporting only research "additional" to what would have occurred anyway, because only in this case the effect of public spending is positive. Thus this component known as "crowding out", "additionality" or "impact" needs to be assessed in order to justify intervention.

2.2 The problem of the R&D/innovation divide

Innovation is the driver of competitiveness and may be triggered through R&D or not. While both kinds can be crucial for profitability and economic growth in this specific context the idea is to deal with R&D-driven innovation, and the link between research and innovation.

Innovation, which is linked to commercialisation, is considered as a business activity, and innovation management deals with decision to be taken with entrepreneurial criteria. European policies thus consider innovation as a business risk similar to any other investment. Competition rules have always appraised it in the same way as tangible investments. This almost suggests ***a divide between R&D and innovation in terms of policy perception***. According to the EU rules no R&D State aid is allowed beyond the stages of "initial prototype, which could not be used commercially" or "initial demonstration projects or pilot projects provided that such projects cannot be converted or used for industrial applications or commercial exploitation". This is however too strict in the sense that it is difficult to decide ex ante what is commericalisable and what is not; ideally even result from fundamental research (in the sense of the mission-oriented basic research mentioned above) can be sold, licensed or commercially applied. Besides, validation of results, which is close to the market would also be a borderline between R&D and innovation. Thus, current thinking recognises that R&D triggered innovation is usually more risky than innovation in tangible investment and the need to bridge R&D with the commercialisation phase is expressed in many cases.

As a consequence policies increasingly recognise the importance of an environment conducive to innovation and, both in terms of institutional building and support mechanisms, they try to facilitate the adoption of an innovation culture. Yet, when it comes to individual companies innovation support is subject to general State aid regulation. Support is offered either easily through the de minimis rule (usually insufficient to trigger change), or through specific sectoral or horizontal (environment, regional development) priorities.

It is argued here that in the current market conditions the cornerstone for leading edge competition is:

- Speed, which requests simultaneous acting and thus blurs the traditional sequential approach of the various stages of R&D
- Interdisciplinarity
- Cooperation

Where research ends and innovation starts under these conditions may sometimes be difficult to say. Examples of research after innovation demonstrate the interrelation: the history of many important ICT innovations for instance involved significant R&D much of which was conducted as part of government programmes in some cases after the market had abandoned the research (OECD 2003). Similarly basic research undertaken in AT&T (Bell Labs) or the PARC lab of Xerox went many times to the market and back to research.

A new regulatory framework for State aid, which recognises innovative activities that lie outside of R&D, could be a positive instrument for free competence and the open market, whilst also providing an indication of those activities that are considered to create a favourable framework for the promotion of technological innovation (European Commission 2001, Innovation Paper No 19).

This can be done either by:

- Extending the R&D State aid rules to include innovation support or by
- Adopting specialised guidelines for State aid for innovation.

It is suggested that the former is the best alternative. The key concept behind the decision should again be the degree of uncertainty associated with any investment. Innovation of a generalised nature is less risky that innovation to science-based innovations for the first time. Thus schemes related to innovations that are a result of an important R&D effort could be linked to the new rules of State aid.

Innovativeness through diffusion is important but less risky and should thus probably continue to be treated as tangible investment.

2.3 Risk, uncertainty and options

As indicated in the theoretical introduction the basic argument for supporting R&D is the inherent uncertainty associated with research activities. ***If there would be no risk and uncertainty there would be no need for R&D support.*** In order to decide, which R&D projects to fund big firms have internal rules and a systematic tension between R&D departments and corporate finance, which is (implicitly or explicitly) resolved by top management. Organised R&D departments use option theory (Nichols 1994, Lint 2000, Luehrman 1998a, b, Hamilton and Mitchell 1990, Lint 1992a, b).

Firms are in a position to attribute risk factors and assess the impact of each research project they undertake, thus resulting in a matrix linking risk with impact, as indicated in the following table. One should note that an implicit assumption often encountered which sets the likelihood of success equal to the stages of the linear model (e.g. fundamental research is high risk, whereas prototype development bears no risk) is utterly misleading in the real world.

	Low potential impact to investor	**Medium potential impact to investor**	**High potential impact to investor**
High likelihood of success		Company Priority	Company Priority
Medium likelihood of success		Potentially justifiable, especially if combined with secondary targets	Potential company priority Justification of aid
Low likelihood of success			Justification of aid

In a simplified way, to illustrate the case of decision making one can assume that management accepts to finance internally projects that are likely to trigger a high positive impact, or even a medium impact, when they have a high potential of success. In certain cases and depending on the overall company strategy and profitability companies may even be willing to support in-house projects that have a medium likelihood of success and potential impact, but it is very unlikely that they would take risks for projects less likely to succeed and not triggering interesting impact at the same time.

State intervention enters exactly at the stage where companies would decide not to take risks and would under-invest. However, the case from the point of view of public intervention becomes more complicated, as actually one would need a new assessment of the same type, where the social returns on investment (i.e. taking diffusion and spillovers into account). The reasoning becomes more complicated, since often the private return of investment is limited by high rates of diffusion. Thus, from a wider point of view the decision matrix should become:

	Low potential impact to the local economy	**Medium potential impact to the local economy**	**High potential impact to the local economy**
High likelihood of success		Justification of aid	Justification of aid
Medium likelihood of success			Justification of aid
Low likelihood of success			Justification of aid

One can create a variety of combinations of social returns, which could lead to precise algorithms on when to accept and when to reject state aid. There are however two major problems, related to this elegant solution

- risk and impact assessments are complicated exercises, loaded with subjective judgements
- such an exercise per project (let alone aggregated at a programme level) would be too costly and time consuming, hence, the idea of introducing risk assessments into the process should be abandoned.

However, one point strongly stressed by the business sector is that the original concept based on theoretical work that *there are no substantial positive externalities if R&D is close to the market* (hence the state should not support R&D in this case) is not valid in the current state of transparency and speed of diffusion. This also leads to contesting the (to a certain extent controversial) divide between R&D and innovation.

2.4 Divergent interpretations within the EU

Defining R&D is a necessity for the EU at various levels and tasks, of which State aid rules are only one. The following policy decisions involve an explicit or implicit understanding of what is R&D, and these are not streamlined within the EU context:

2.4.1: The Lisbon Agenda

Policies for enhancing competitiveness and hence the Lisbon agenda itself understand that the business sector views R&D only as an input for increasing private returns to investment and not as the origin of spillovers. Thus, when speaking of the most competitive economy, or the Barcelona targets EU and national policies are *trying to make support schemes more attractive to the whole population of EU companies*[129].

[129] Innobarometer 2004 shows that only 12% use the support for which they are eligible, which indicates that further coverage of public initiatives could be achieved, Entreprise Europe News Update, enterprise-europe-no-response@cec.eu.int

Several public support programmes are highly rated by EU firms, with support for developing collaboration and training ranked first, followed by programmes to support adoption of process technology and research and development. Support for innovation is considered to be the most effective in Germany, but the country is also highlighted as having the most burdensome regulation (www.cordis.lu/innovation).

This suggests that, in terms of policies the EU is likely to interpret R&D very broadly, to include R&D services for diffusion and adaptation, in particular in the case of SMEs. Such interpretations are very close to R&D related innovation.

2.4.2 The Community dimension and the EU Framework Programmes: concepts and eligible costs

The FP has a broad view on the rules and interpretations of the way of sharing R&D results in the case of R&D consortia. Although the rules for participation contain some clear limits to the freedom of partners in designing their IPR regime and there are absolute limits in the form of the treaty's antitrust rules in the area of technology transfer as well as on research co-operation agreements, industrial partners perceive the rules as clear and fair, leaving the necessary degrees of freedom, when signing a consortium agreement. By contrast they feel that in paragraph 2.4 of the State aid rules the case is not sufficiently clear and is prone to misinterpretations: in a specific case in a member state an over-careful interpretation imposes to companies to pay royalties to their research partners even for their own results in the context of the partnership, resulting in a need to pay for intellectual property rights to universities, which may strongly reduce the expected impact of the project. Such an interpretation has a strong adverse effect and acts as a dis-incentive for university-industry cooperation.

Eligible costs were traditionally broken down by basic categories like research personnel, scientific equipment, travel expenditure, overheads etc. This was and remains in many instances the traditional way for control. Research teams are requested to budget expected expenditures by detailed category and apply (often different) shares of support. Potential divergences from the originally conceived budget have to be reported and special permission may be needed. A new approach in the EU FP-6 allows for more accountability of each research partner and the coordinator, stipulating that partners submit budgets by work package rather than analytical categories. The aggregation is made by broader categories, notably

- R&D expenditure
- Demonstration and training
- Management activities.

The coordinator is then accountable for putting together the information for all partners and controlling for the compatibility of the overall budget with the work delivered. An auditors' report is requested then for the cost statements. This approach strongly simplifies procedures (cost statements are easier and there is no need for revisions when it is necessary to shift costs within budget categories) and gives a higher accountability to research teams.

2.5 Perceptions from the business sector

The following analysis reflects the position of those representatives of the business sector who have taken an explicit position on the problem:

2.5.1 R&D State aid rules: the rationale of balancing competition and the R&D support rationale

A key issue, when dealing with the perception of companies is the different position between

- big firms and collective representation at European level, which mainly represent multinational companies fighting for leading edge technologies at global level,
- small companies with growth potential, mainly new technology based firms envisaging either global competition in niche markets or, in exceptional cases, a very sharp growth based on appropriable technologies and
- average, traditional companies, which in the established terminology are “supplier dominated” in their innovation patterns.

Big companies are particularly keen to accept the general principle that it has to be ensured that public support programmes for R&D are not leading to unfair competition and, in order to assure that, it *requests a clear set of rules ensuring a level playing field (EICTA 2000, UNICE 2004, IRDAC 1998).* However, it is important to note that in terms of implementation there are two trade offs and policy makers are requested to take decisions on where to draw the line:

1. The more refined the set of rules the higher the cost it takes to check for compliance, unless some basic principles are established, which give indications of averages to be mechanistically applied; which averages and where to go for a more detailed analysis are key issues in that respect.
2. The control of compliance by a centralised authority requests time, while a decentralised control, which is faster, is amendable to different rules of interpretation.

Small companies with growth potential are putting forward the position that in their case funding is a different kind of barrier than in the case of established companies. Decisions are not taken through the link of risk and impact, simply because funding is a generalised constraint. Even projects with low risk and high impact need to be postponed or even eliminated because of a genuine lack of funds. This explains why the mobility within the top US firms (where both specific schemes and the availability of private venture capital and business angels at the seed phases eliminate this constraint) is higher than in the corresponding population in Europe. Thus, their point is that *State aid rules should not so much take into consideration what type of expenditure is eligible, or what are the ceilings in the regular case, but made a clear distinction as to whom the support is addressed.*

Average SMEs are a target population for most support programmes. Development theory suggests that for them support schemes should be extremely generous, since they should address a change of their mentality on risk and growth. It is unlikely that so generous schemes would be incompatible with State aid rules.

Fundamental research, industrial research and precompetitive development activity and ceilings

The general perception of the business sector (UNICE 2004, EICTA 2000, IRDAC 1998) is that one should give up the outdated distinction between industrial research and pre-competitive development and replace them by a single category "industrial R&D", including prototyping and software R&D but excluding product and service development. According to IRDAC in this case the process should allow for all industrial R&D a maximum aid intensity of 50%, corresponding to the usual funding rate in the Framework Programme and remaining within the limits of the former WTO rules[130].

UNICE similarly states that the current framework for assessing R&D projects on the basis of the separate, sequential R&D stages from the outdated linear innovation model is incompatible with strict time-to-market requirements and should therefore be updated to reflect today's concurrent, iterative and interactive industrial innovation processes with constant market feedback. In UNICE's view the Commission should therefore ***abolish the distinction between industrial research and precompetitive development activity and create a single category "Industrial Research and Technological Development (RTD)***".

As a general rule, the gross aid intensity for all "industrial RTD" should not exceed 50% of the eligible costs of the project. The new category "industrial RTD" should also include prototypes (as long as the primary objective is to make further improvements) and computer software (if its completion depends on the development of a scientific and/or technical advance and its aim is the resolution of a scientific and/or technological uncertainty on a systematic basis). Routine or periodic changes made to products, processes and services, on the other hand, should be excluded. This would also be in line with the broader definitions of R&D as provided in the Commission Regulation on the application of Article 81 (3) EC to categories of research and development agreements, and the OECD guidelines for the classification of scientific and technological activities (Frascati Manual). UNICE suggest that the Commission investigates whether these broader definitions could be used for distinguishing industrial RTD and closely related innovation-oriented activities qualifying for R&D aid from business activities disqualifying for such aid (UNICE 2004).

IRDAC goes a step further to ***request an extension of the definition of R&D to include the validation of R&D results***. The Round Table mentioned that today industry is using research carriers in all R&D stages (and not only at the final stage of a research project). The reasons for this are:

- To be able to choose concepts for potential future products
- To focus technology developments on realistic problems
- To study the interplay of technologies
- To test and validate new ideas in a realistic environment.

[130] 75% for industrial research; 50% for precompetitive development

As yet, the Commission seems to qualify any R&D activity that pertains to validation and user interaction in a realistic application environment as relating to a prototype not eligible for State aid. In this respect, the Community Framework for State aid for R&D only allows aid for initial prototypes that cannot be used commercially, and for initial demonstration projects or pilot projects that cannot be converted or used for industrial applications or commercial exploitation.
The Round Table also pointed to the danger that if the European Commission continues to restrict State aid for prototyping, European industry will go abroad and do its prototyping outside of Europe. It was also mentioned that in the United States prototyping is often financed up to 100% by public authorities. However, in those cases it is often classified as "public procurement'. This leads to the need to ***view mission-oriented research linked to special, not yet generally available, products for public purchases, as a special category for research***.

- ✓ Today in industry, prototypes are not only used at the end of the R&D phase, but are integrated activities in all R&D stages and therefore essential elements in successful innovation.
- ✓ New principles should be used which relate to the "complexity of the project", the "feasibility of the project", the "number of different actors involved", the "risk level" and the "time element (IRDAC 1998).

The general perception of policy regulation is that for an aid to be compatible with the non-distortion principle additionality, a so-called incentive effect of R&D aid is important. This is however extremely hard to assess and measure, since it refers to anti-monde scenarios, namely what would happen, if the aid was not available. A rule of the thumb used to deal with the problem is ***the core business and non-core business divide.*** This is again an over simplification of the business reality. One cannot a priori disqualify aid for R&D projects within a firm's core business or with clear market potential (EICTA 2000): the boundaries between core business and non-core business shift rapidly both as a result of technological progress (biotechnology can suddenly become an integral part of ICT core business in the future) and of company strategy (as in the case of a decision to diversify). Other elements are thus more relevant.

Similarly UNICE considers that the Commission's interpretation of this requirement should not put European companies at a competitive disadvantage vis-à-vis their competitors located outside the EU, who are not suffering from comparable constraints. In practice, it is very difficult to prove that certain R&D activities are carried out in addition to normal day-to-day operations. In any case the Commission should not *a priopi* disqualify aid for R&D projects that fall within a firm's core business or which have clear market potential. IRDAC gives a more detailed outline of this strand of thought. The Round Table mentioned that this way of reasoning completely out of line with economic reality, whereby i**ncreasingly industry is concentration its activities on its internal core business and peripheral activities are sold off.** Today, no sensible business manager will launch R&D activities which are outside of his industry's scope. However, it is exactly this kind of activity which the European Commission would allow to be supported by the Member States. If the current way of thinking of the European Commission is continued, it will in practice lead to a situation whereby Member States are prevented from effectively encouraging industrial R&D through State aid.

As an alternative to the additionality principal, the Round Table proposed to use that **"risk"** and **"time"**. In practice, this would mean that MSs may provide State aid for R&D in case the foreseen research (though being related to the core business of a company) involves a high level of risk and is of a medium to long-term nature.

Finally the business sector has strong views on how to approach the case of Public-private partnerships in general and in particular the case of university-industry cooperation. To address the "European Paradox", which refers to Europe's notoriously poor track record in translating the results from its strong public research base into successful innovative products and services in the market place, the links between industry and public research need to be strengthened, for example by means of public-private R&D partnerships. Unfortunately, the framework's provisions for "R&D carried out by public non-profit making higher education or research establishments on behalf of or in collaboration with industry" are insufficiently attractive to industry. They are ambiguous and imprecise, and therefore prone to interpretation problems, particularly regarding IPR issues.

For example, one of alternative situations of permitted State aid is "where the public non-profit-making establishment receives from the industrial participants compensation equivalent to the market price for the intellectual property rights which result from the research project and which are held by those industrial participants, and where the results which do not give rise to intellectual property rights may be widely disseminated to interested third parties". In this case it is not clear whether and how such compensation would take account of the contributions that the industrial participants may make to the project by means of their own R&D activities, financial payments, non-financial ("in-kind") support or pre-existing know-how (UNICE 2004).

2.5.2 R&D State aid rules: the danger of dissuasion

The procedures foreseen may be excellent in terms of design but there is a trade off between precision and time to decide. If precision this can trigger problems at various levels:

1. National or regional authorities (in particular those in less favoured regions) may be inclined to prioritise development investments in infrastructure instead of R&D and innovation to avoid the often lengthy and cumbersome procedure of notification/decision at the EU level.
2. Discrepancies in the implementation, since national authorities, which are more formal and strict in interpretation may by themselves create a distortion by disadvantaging their own local companies compared to more relaxed or even risky cases
3. In some cases industry will not consider applying for public funding for product development or manufacturing because the lengthy application and approval processes are incompatible with time-to-market requirements (EICTA 2000).

One of the problems emerging from the R&D State aid framework is that it is amenable to *different interpretations at the national/regional level.* The case of ***potential different interpretations, in a case so fluid and intangible as research, is***

also one of the arguments against the adoption of block exemptions, which would facilitate procedures but might create more distortions.

3. Evidence from policy implementation

As science, research and innovation policy prove to be important there are more and more support schemes adopted and decisions taken, despite the limitations of our knowledge on how to perfectly design and apply these policies. Evidence from the systematic study of policy implementation is a valuable input for further work. As there has never been a case, which was serious enough to reach the Court of Justice two types of policy are studied to see how they treat categories of R&D and innovation practically:

- measures supporting R&D with the aim of enhancing innovation and
- application of State aid for R&D and innovation.

3.1 Evidence from State aid Decisions on R&D policies

There are 188 R&D State aid notified and non-notified cases (for a full coverage see Analytical Table 2.1 in Appendix 2 of Part IV) in the European Union. These cases were registered by the Commission during the period 1998-2004 and decisions were reached under "Preliminary examination". This means that the cases examined did not give rise to doubts and were closed after the preliminary examination with a decision not to raise objections to the aid because it was compatible with the common market (N & NN case classification).

Some initial findings regarding cases approved during "Preliminary examination" consist of the following points (see Appendix 3 of Part IV):

- As almost 54% of the examined cases are not categorised by sector, observations offer only an indication of sectoral variations. Within this limit, *R&D State aid cases directed to All sectors* (28 schemes requesting mainly grants or soft loans or a combination of these) *are of note, followed by Electrical & Electronic Manufacturing, Manufacturing and Shipbuilding sectors* (the later altogether 32 cases).
- *Schemes stand for the majority of the approved R&D State aid cases* (149 cases representing 79% of total case types), while individual applications are also a noteworthy amount (remaining 39 cases representing a 21% of total case types).
- *Average duration of R&D State aid is approximately 5,3 years* for the 141 cases for which we have available data. Nonetheless, *there are significant variations between sectors (still this is indicative due to the lack of sectoral categorization for all cases)*. State aid duration ranges from 1 year in a Handicraft Manufacturing Industry case to 11 years in Manufacturing and non-specified sector cases. Services, agriculture, tourism, steel, motor vehicles belong to the sectors with a less than 3,5 years approved State aid. In general high periods of R&D State aid can be observed in all sector, Manufacturing, Electrical & Electronic Manufacturing, Chemical & Pharmaceutical Industry, as well as in non-specified sector cases.
- "Preliminary examination" by the Commission has taken from less than 1 and up to 31 months according to data available in the cases examined here. Still, these are rather exceptional cases and *most cases present an average of a 5 to 6 month examination* according to the difference between notification (or registration) date

and decision date. *Depending on the case itself, the case type, as well as the aid instrument requested the "Preliminary examination" process takes more or less time*. In general grants or cases regarding international collaboration or grants take less time, while individual applications need more time to reach a relevant decision compared to schemes.

- *As for the aid instrument approved grants represent the magnitude of approved R&D State aid cases* (116 cases representing almost 62% of total cases), followed combinations including grants, as well as a reimbursable grant and/or a soft loan and/or an interest subsidy and/or an equity loan.

Analytical Table 2.2 (see Appendix 2 of Part IV) presents separately 16 R&D State aid cases registrated by the Commission at the period between 1998-2003, which were not included in the previously mentioned tables. Of these, 5 cases reached decision during "Preliminary examination", they did not give rise to doubts and were closed after the preliminary examination with a decision that the measure does not constitute aid. Table 2 also includes 11 cases in which the Commission held doubts as to the compatibility of aid with the common market and a formal investigation was opened (C case classification). Of these 11 cases:

- *2 concern cases with a positive decision (actually one of these cases refers to an individual application for the Vasco region in Spain reaching both conditional and positive decision after 27 months of examination by the Commission),*
- *2 concern conditional decision cases,*
- *3 concern cases with a negative decision (in the steel and motor vehicle sectors), and*
- *4 concern cases in which the Member State has withdrawn the origin*al notification (*2 of which were individual applications regarding the steel sector).*

Cases of State aid strictly addressed to Innovation (meaning that they do not include R&D aspects) are not as many and no general conclusions can be drawn. An analytical framework is presented on Appendix 4 of Part IV, together with the most interesting examples.

3.2 The most popular support schemes: evidence from the Trendchart database

In this section of the Report, we present evidence based on Trend Chart material concerning measures supporting R&D with the aim of enhancing innovation. Projects have been selected on the basis that the "Action Plan Objective" addressed by the measure is focused on the R&D aspect. Appendices IV.5-9 present the detailed and synthetic evidence.

The analysis concerns the "Gearing Research to Innovation" objective as mentioned in the Trend Chart database. More specifically, projects examined in our work address at least one of the following categories:

Category I. Strategic vision of R&D
Category II. Strengthening company research
Category III. Start up of technology based companies
Category IV. Co-operation Research/Universities/Companies
Category V. Absorption of technologies by SME's

Many of these measures are overlapping as they have mixed targets addressing at least one of the above-mentioned targets or also others (such as Fostering an Innovation Culture, Establishing a Framework conducive to Innovation). Throughout examination of 331 cases we provide information of relevant R&D support programmes concerning 27 countries (including most of EU 25 members plus Bulgaria, Romania, Liechtenstein, Israel, Iceland and Norway). Measures are analysed and grouped as to the aspect of innovation addressed, type of beneficiaries, co-operation as an eligibility criteria, mode of funding, eligible costs covered, the impact and overall appraisal of the measure.

The Trend Chart projects described in this section are broad and extensive, and being a varying set of measures, the implementation of these programs shows that over time R&D policy has evolved in order to meet the needs of EU objectives in this field. While there are many programs that are still new, in many other cases the effects (even though not full effects yet) have been realised in a fairly positive manner.

Main areas of R&D policy for innovation concern

An overview of Action Lines addressed by the Trend Chart database (http://trendchart.cordis.lu/) indicates a trend for innovation policy priorities to be focused within the area of '*gearing research to innovation*', in both the EU Member States and Associate States, and the Accession Countries.

Within this specific Action Line, our work confirms the strong company related objective of implemented measures. More specifically, Appendix 6 of Part IV provides an overall categorisation of all existing Trend Chart measures relating to "gearing research to innovation" Action Line by objective and by allocated funds. The breakdown of the 331 cases according to the five categories of the R&D objective (hereafter "Sub themes" as in the Trend Chart wording), has shown that Strengthening Company Research is a highly ranked priority (regarding 4 out of 10 measures). Start-ups, intensified co-operation between research and industry and strengthening the ability of SMEs to absorb technologies and know-how are almost equally ranked in a very high position and seem to be viewed as of certain importance in terms of national policy formulation. Last of all, Strategic Vision for R&D was of less concern (only 48 measures).

Besides mixed targets between the five main "Sub themes" examined here, a fairly strong link with objectives in other Action lines also exist. More specifically, mainly:

- In the case of 86 measures with an R&D objective there was a link also with a financing innovation objective,
- In the case of 84 measures with an R&D objective there was a link also with a promotion of clustering & cooperation for innovation objective and
- In the case of 64 measures with an R&D objective there was a link also with a Innovation & Management objective.

In general, the introduction of these programs shows that over time R&D policy for innovation has evolved to meet the needs mainly of company related objectives, whereas clustering, cooperation, strengthening of SME's ability to absorb knowledge and addressing financial constraints are of noteworthy importance.

The comparison of the distribution of measures both by objective and budgets attributed to these objectives is indicative of the relative amounts of effort dedicated to relevant policy formulation. Although information on the budgeting of measures is far from being sufficient for a deep analysis, nonetheless, that there is room for improving support especially in the case of strategic vision of R&D, as well as for start ups, cooperations and strengthening the ability of SMEs to absorb technologies and know-how.

Actually, although a number of countries have introduced initiatives aimed at developing long-term strategic approaches to research and its applications, a more strategic approach to S&T policy-making with regard to innovation, in the context of the 'knowledge society/economy' remains a challenge for countries in our analysis both in terms of measures being introduced and funds allocated for these measures.

Overview of types of research

Here, a more in depth analysis of the five "Sub-themes" (Categories) related to R&D policy for innovation places the types of innovative activity on some kind of a "scale of importance". This was decided, as the straightforward counting of policy-relevant measures provides only a partial indicator of this kind of support activity and policy intent (Appendix 9.2 of Part IV).

Within the Trend Chart database 12 types of measures addressing the aspects of innovation process are identified:

1. Promotion of entrepreneurship/start up (including incubators)
2. Awareness raising amongst firms on innovation
3. Pre-competitive research
4. Applied industrial research
5. Development/prototype creation
6. Commercialisation of innovation (including IPR)
7. Industrial design
8. Co-operation promotion and clustering
9. Diffusion of technologies in enterprises
10. Innovation management tools (incl. quality)
11. Improving the legal and regulatory environment
12. Not applicable/other

The most important points are the following:

1. Looking across *all categories* of measures: Diffusion of technologies in enterprises, Promotion of entrepreneurship/start up (including incubators), Applied industrial research, Development/prototype creation and Co-operation promotion and clustering are of relative importance. Nonetheless, there is a gap in policy effort between the previously mentioned aspects and Improving the legal and regulatory environment and Industrial design.

2. Variations in priorities exist both between Sub Themes/Categories and in comparison with the all categories sum.

3. *Strategic vision for R&D* (Cat. 1) measures present a fairly weak relationship with most aspects of the innovation process. Some stronger links exist with Applied industrial research and Co-operation promotion and clustering, as measures have been introduced fostering the development of ideas into operational form and others promoting intra-sectoral collaboration and cooperation.

4. *Strengthening research carried out by companies* (Cat. 2) involves measures designed to encourage and strengthen the performance of research within industry Actually, our analysis has shown a relative strong effort towards measures addressing Pre-competitive research, Applied industrial research or Development/prototype creation issues. A somewhat strong link also exists with cases addressing Commercialisation of innovation (including IPR), Co-operation promotion and clustering or Diffusion of technologies in enterprises issues. Indeed, within the context of increasing R&D spending, EU member states have produced relevant effort within their policy-making mechanisms.
5. The *Intensified co-operation Research/Universities/Companies* (Cat. 4) category involves measures with a pattern similar to that of the previous category, this reflecting the effort to develop closer links between the producers and users of technology towards the direction industry believes there could be a greater commercial benefit. Applied industrial research is a firm component of innovative activity in both (this and the previous) "Sub-themes"/categories.
6. *Start up of technology based companies* (Cat. 3), an area of high priority focus, reports firm links (as expected) with the promotion of entrepreneurship and fairly strong ones with aspects such as Awareness raising amongst firms on innovation, Development/prototype creation, Commercialisation of innovation (including IPR), Co-operation promotion and clustering, Diffusion of technologies in enterprises or Innovation management tools.
7. Lastly, *Absorption of technologies by SME's* (Cat. 5) includes measures that aim to improve the capacity of SMEs to carry out innovation activities, particularly those at the research end of the innovation spectrum (i.e. Commercialisation of innovation).

To sum up the previous observations, the distribution of existing measures according to type of innovative activity shows that Applied industrial research, Co-operation promotion and clustering, Commercialisation of innovation (including IPR), as well as Development/prototype creation and Pre-competitive research, clearly form the key areas of focus for policy measures designed to encourage and strengthen the performance of research within industry, to create closer links between the producers and users of technology and to strengthen the ability of SMEs to absorb technologies and know-how.

Distribution by type of beneficiaries

Appendix 9.3 of Part IV presents the relative importance of existing Trend Chart measures relating to "gearing research to innovation" Action Line according to "Sub Theme"/Category and type of beneficiary. Again we believe that the straightforward counting of policy-relevant measures provides only a partial indicator of relevant support activity and policy intent and therefore data is examined on a relative importance scale**.** The overall picture shows, as expected, "SMEs" clearly form the largest category of beneficiaries. The second highest target category is "all companies", followed closely by "Higher education institutions research units/centres". Actually, there is greatest emphasis on increasing efforts to target enterprises and especially SME'S with a variety of different support measures. As for the case of research institutes and universities, we can confirm the more general observation "*that many governments are increasing their efforts to see if the results of research in the public sector can be commercialised*" (Trend Chart, 2003). One can also observe the relatively low participation of categories such as "trade unions", "spin-offs", "Consultancies and other private service providers (for-profit)".

When examining the breakdown by Sub-theme/category the relative importance of different beneficiaries varies:

1. SME's clearly form the largest target categories in the case of high tech start-ups and of course in strengthening the ability of SMEs to absorb technologies and know-how.
2. All companies form the largest target categories in the case of encouraging and strengthening the performance of research within industry, as well as intensified co-operation between research, universities and companies (also HEI research units in the latter category).
3. As for the strategic vision for R&D category the main beneficiaries derive from HEI research units (in a large extent), followed by all companies, non HEI research institutions, business organizations and to a less (but still important) extent from individual expertise and technology innovation centres.

Regardless of the fact that companies and SME's form the main beneficiaries of R&D policy for innovation and while universities and research centres are intensifying their presence, there is a need for improving future involvement, especially when observing absolute figures. For example (see Appendix 7 of Part IV) out of the 331 cases examined here and more specifically among the 48 focusing on "Strategic Vision for R&D companies" are beneficiaries in only 19 measures and SME's in 7!!. A second example, this in regard with the EU priority area of encouraging "co-operation between Research/Universities/Companies": among the 124 measures some 19 measures involve SME's.

Cooperation: Is it mandatory or optional?

In light of the focus on cooperation and networking, we looked into a set of data derived from the Trend Chart database on target group eligibility and more specifically on considering the following fields:

- Whether co-operation/networking is mandatory (e.g.; cluster programme)
- Whether co-operation/networking is optional (e.g.; associating SMEs as users)
- Whether only proposals from single organizations are accepted

Based on a similar matrix as previously, Appendix 9.4 of Part IV addresses the above questions in the case of all categories, as well as for Sub-theme/Categories, as mentioned in the Trend Chart database for a total of 137 measures.

Co-operation/networking seems to be mostly mandatory, but especially in the case of Strategic Vision of R&D this is exceptionally high (3 out of 5 measures). Proposals from single organizations is the case for 1 out of 5 measures (even less in the case of Strategic Vision of R&D).

These observations, combined with others in previous sections, show the effort to support interact between firms and the research base. Here, we see that firms are encouraged to collaborate and source information from 'institutional sources', defined to include universities and higher education institutes, and government and private sector non-profit research institutes.

However, it is important to stress that, from these types of figures, it is not possible to tell whether public programmes have been effective in inducing firms to become innovative. Nonetheless, rich bibliography, has pointed out that while several parties might find it difficult to commit them to collaborating on a research project that involves a large fixed cost or high-risk government intervention might be beneficial in this case by subsidising the fixed costs of the project or by underwriting the risk involved in the fixed cost.

A look into the impact (See Appendix 8 of Part IV, as far as there was available information) of some of the 62 measures concerning mandatory cooperation shows only one case of replacement of the measure, while in general there was a medium to high positive appraisal of these measures in terms of:

1. Relevance with respect to national S&T
2. Take up of the measure by the target group (e.g. absorption of available grant funding by SMEs, rate of coverage of target group)
3. Management effectiveness (e.g. extent to which delivery process respects planned timing, etc...)
4. Extent to which measure has achieved results (e.g. % of industrial research projects resulting in prototype)
5. Extent to which the measure has contributed to overall objectives (e.g. reduction in business death rate for high-tech firms).

4. Conclusions and considerations on policy directions

An effective policy is inevitably context specific. Policy rules have to be constantly revised to be compatible with the rapidly changing environment and it is important to make sure that they are not obsolete or at odds with industrial reality. State aid, when justified and legitimate, need to be efficient and effective and not to be hampered by the checks and balances. The development model of the advanced countries and the international competitive pressures are reformulating priorities, while still requesting to strike a balance between R&D support and competition: while in the past competition was the cornerstone and ways to eliminate market failure were sought after, now the target is to increase R&D without distorting competition. This is important both for supporting existing companies and creating new ones, but also for Europe to remain an attractive place for high quality inward investment. Thus the types of categories to be funded, the way they are approached and control and the procedures used are a major subject of investigation.

Several conclusions can be formulated following the investigation of the existing categories and the views of various actors:

1. The *standardised R&D and innovation definitions are useful for surveys and statistical coverage but unlikely to reflect and accurately describe the complexity of the R&D and its relation to innovation*. The neatly fitting linear approach and the extensive standardised definitions of the Frascati and Oslo Manuals are insufficient to cope with reality.

2. The best way to approach the justification for intervention is through the risk and uncertainty associated to a research project; however, it is too difficult and costly to makes such assessments ex ante, let alone define them for whole programmes. But *support schemes designed especially for high risk research should undoubtedly be favoured.*
3. The abandonment of the linear model in the theory should be accompanied by a broader view in policy implementation. *Allowing for more generous schemes when they fund higher risk and incorporating activities closer to innovation like instruments for validation of research results.*
4. There is a need to further investigate the potential distinction between *blue sky and mission-oriented basic research;* this differentiation is not sufficiently studied or documented and not included in the standard R&D definitions but as complexity rises it needs to be taken into the agenda.
5. No specific request for generalised higher ceilings was found as a basic argument or expressed by representatives of the business sector.
6. There are unanimous reservations on the way the incentive effect is perceived as a need to research in non-core business activities. A new approach is needed.
7. The interaction with innovation is another relevant point. *R&D related and science based innovations are more risk loaded than non-R&D innovation and should thus be treated differently, allowing for support* as an ultimate stage of R&D, provided the connection between the two and a strong element of risk can be demonstrated.
8. However, an important conclusion is that *it is less the type of expenditure which should prescribe the need for a potential higher ceiling and more the type of project and/or the type of company requesting support*. Small firms with growth potential and projects of generalised European interest (mission-oriented research) merit higher funding, up to 75% or even 100%.
9. Both for existing schemes and for potential new categories of actors and projects, as mentioned above, *clear rules are needed*. Unclear rules are subject to different interpretations and create the distortions they were hoping to prevent. The problem with the clarity of rules and in particular with the procedures controlling them is that they trigger trade offs: the better the control mechanisms the higher the time to decision and the higher the time to decision the more it acts as a dissuasion for companies to apply for support.
10. The *dissuasion effect* is difficult to prove. There is a variety of R&D support schemes in all member states, and there are almost no negative decisions regarding notifications. However, from individual reactions it is suggested that in many cases innovative schemes were not promoted and there is limited experimentation of sheer fear of too lengthy procedures.

As a consequence the direction of policies should envisage to:

1. Realise that procedures and types of projects and companies matter more than ceilings.
2. Make governance and procedures as easy as possible.
3. Allow for a merger of categories of research that cannot be distinguished among themselves in real life; accept also to go further down the line (in the jargon of the conventional linear thinking) by allowing support for validation instruments and risk loaded, science-based innovations;.

4. If not adopting a "block exemption" a generalised approach of "reasonable expenditure" rather than detailed and bureaucratic reporting on individual items of eligible costs reduces bureaucracy without substantially increasing the possibility to circumvent rules.
5. Offer selectively a more generous treatment to companies that do not have the means to finance growth promising activities themselves (which includes the difficulty of allowing for different ceilings for the same kind of projects); for these particular categories the combination of R&D and innovation support will be acceptable; this should apply mainly to high-risk, high-growth and high-tech innovative companies; for traditional SMEs de minimis may in general be sufficient.

PART V

Analysis of the leverage effect of R&D State aid, in terms of its potential to stimulate additional private R&D investment

1. Policy Effectiveness Evaluation: Role and Implementation Difficulties

Is intervention in the form of State aid to R&D sufficiently effective in correcting market failures to justify its often substantial cost? A number of problems are worth mentioning in relation to attempts to evaluate policy effectiveness:

1. First, is the **problem of measurability –** it is notoriously difficult to measure the extent of a market failure. This problem arises mainly because a large number of factors, e.g. appropriability or framework conditions, simultaneously influence the market failure. So in practice it is almost impossible to determine the exact amount of State aid needed to eliminate a market failure, due to asymmetric or incomplete information. Thus, in practice, measuring the effectiveness of State aid policy does not usually imply that in fact we measure the extent of market failures and compare these to the actual amount of aid given. It usually implies that we are just measuring the extent to which State aid have satisfied some specific policy objective, such as, raising the private investment in R&D and innovation[131].
2. Ex post, measuring the impact of State aid is also difficult since now we have to face the problem of the **"counterfactual"** (or Deadweight) – we do not know what would have happened in the absence of State aid). Venetoklis (2000, p. 15) demonstrates the importance of the use of a counterfactual. The use of a counterfactual (as a benchmark for the results), provides for more balanced judgements than studies that do not use a counterfactual, or where the counterfactual was based on estimates from the recipient firms[132].
3. Assuming that the specific policy objective of raising the private investment in R&D is used, then it should be understood that State aid could potentially lead to **private funding displacement**, as when the aid leads to:
   a) The recipient to use it to substitute for investment it would otherwise had undertaken, or to,
   b) The rival firms to reduce their investment in response to the change in the "technology gap"[133], or to
   c) Crowding-out (or, substitution effects) - as when due to an inelastic supply of R&D personnel it leads to an increase in the price of resources – e..g. skilled labour or researchers – used by firms[134].

This is the issue of **additionality** of State aid, respectively at the firm, industry and aggregate levels. At the firm level additionality requires that the firm increases its R&D investment by more than the amount of aid it receives. It should be noted that at the industry and aggregate levels the displacement effects above could well be outweighed by the positive externalities (spillovers) generated by the State aid. In practice, additionality has especially been measured in the sphere of R&D subsidies. These studies have focussed on three questions:

[131] See also L-H Roller, H. W. Friederiszick, and D. J. Neven (2004). It should be noted however that this approach has the drawback that even if additionality is proved this does not show that money is well spent: when we do not know how much higher is social than private return aid may be leading to excessive private investment.

[132] Mosselman, M., Prince, Y. and R. Kemp, (2004). Traditionally, deadweight has been researched using a control group of nonbeneficiaries (see for instance Turok, 1991). However, this approach has some drawbacks, one of which is the selection problem. This problem involves that there may be structural differences between supported firms and unsupported firms (selection bias). These differences may bias a sound comparison between the research population and the control group. There are statistical procedures to test for the selection bias (Storey, 2002).

[133] However, the change in the "technology gap" could also **increase** the incentives to invest on R&D by rivals. Also rivals could increase their investments IF the state aid generates additional "spillovers".

[134] The empirical evidence which will be reviewed later on in this report does not provide any conclusive support for this argument at least for state-aid to R&D.

a) The question of *input additionality*; did firms spent more of their own resources on the intended activities because they were subsidised?[135].
b) The question of *output additionality*; did the activities' outputs increase due to the support scheme? (e.g. the number of innovations, patents, jobs, firm, startups, etc.)[136].
c) The question of *behavioural additionality*; permanent changes in firm behaviour, inducing a more efficient transformation of inputs into outputs[137].

4. Finally, State aid can potentially create serious **distortions to market competition and misallocation of resources,** by selectively conferring advantages to specific firms, sectors or technology / research areas, that may result indirectly in *reductions* in social welfare – overall and, many times, in the country concerned. Indeed, the fear of a harmful subsidy race, with countries or regions competing against each other for inward investment, or promoting damaging delocalization, has always been a strong factor in State aid control[138].

In the following sections of this Part we examine the accumulated empirical evidence on the effects of R&D support. We distinguish between R&D Subsidies (Section 2), Fiscal Incentives (Section 3), Support for Collaborative R&D (Section 4) and Guarantees (Section 5). Section 6 examines the main factors that affect effectiveness of State aid to R&D in EU.

2. The Impact of R&D Subsidies

Introduction

Given that the social return is higher than the private return of R&D the goal of a subsidy is quite clear: by granting a subsidy, the public investor hopes that additional research projects will take place compared to the ones that would have been undertaken without the public support. The main difficulty in assuring additionality arises from the *asymmetric information* between the subsidized firm and the government − the government does not know ex ante which kind of effect the subsidy will entail, bearing in mind that the level of R&D expenditures is the result of an internal decision process within the firm and so are the reactions to R&D subsidies[139]. As indicated above, one should distinguish between 'input' additionality, 'output' additionality and 'behavioural' additionality. Traditionally, studies on the effect of public R&D grants on private R&D have focused on concepts such as output and input additionality. The preferred methodology of these studies has been econometric in nature. Although these studies certainly have had their benefits, they have not produced completely definite conclusions. Some studies (mostly American) demonstrated 'substitution' effects, even though the majority (mostly European)

[135]Mosselman, M., Prince, Y. and R. Kemp, (2004). A formal model for calculating input additionality is presented by Lach and Sauer (2001).
[136] Mosselman, M., Prince, Y. and R. Kemp, (2004). A formal model for calculating output additionality in relation to displacement is presented by Meeusen and Janssens (2000)).
[137] Mosselman, M., Prince, Y. and R. Kemp, (2004). Measuring additionality is difficult, but not impossible. Brouwer et al. (2002) used a questionnaire combined with econometric analyses to measure input additionality. They analyse whether or not the investments in R&D increased more than the value of the R&D subsidy that the recipient firm obtained. Brofoss et al. (2004) measured output additionality through the use of a questionnaire, but approached the matter in a more qualitative way. They included questions such as 'how important was the subsidy for getting the project started at all?'. Clarysse et al. (2004) have developed and tested a questionnaire tool for measuring input, output and behavioural additionality of R&D grants. An alternative way is through the use of control groups.
[138] See also speech delivered to the European Parliament on 26 May 2003 on "Objectives of state-aid policy in the European Union and in the international context" by the then Director of DG COMP.
[139] Streicher G., Schibany A., and Gretzmacher N. (2004).

indicated 'additionality'[140]. Further, these studies were limited to a quantitative aspect of additionality[141]. However, recently qualitative studies have addressed the issue of additionality in all its dimensions.

Studies can be distinguished by whether they employ a firm-level or more aggregate (industry or macroeconomic) approach. As Van Pottelsberghe & Guellec (2001) indicate, as compared to the former, the higher aggregation approach allows indirect effects of policies - negative as well as positive spillovers - to be captured. These effects may be quite important. A firm benefiting from subsidies is likely to boost its own R&D activity, but the R&D activity of the competing firms might decline, for instance because the financial advantage given to the recipient might reduce their rate of return. Negative externalities can also occur between industries, as shown by Nadiri and Mamuneas (1996). Conversely, the recipient firm's research may generate knowledge spillovers that will also be beneficial to its competitors. The potential presence of these effects makes the case for empirical studies at the aggregate level. A second advantage of working at the macroeconomic level is that overall government funding of R&D can be considered as exogenous with respect to privately funded R&D. At the firm level, the relevance of the assumption of exogeneity is questionable because public authorities do not provide R&D subsidies to randomly selected companies. Or, in the words of Lichtenberg (1984); "*Federal contracts do not descend upon firms like manna from heaven*". Public authorities are more inclined to support firms that already perform R&D and that have good innovative records. This view is supported by recent empirical evidence (Czarnitzki and Fier (2001) and Wallsten (2000)) at the firm level. A positive and significant relationship between a firm's R&D and the government funds it received cannot be taken as an evidence of the efficiency of government support. This argument may also apply, though to a lesser degree, to cross-industry studies since R&D subsidies are mainly directed towards R&D intensive industries.

At the macro-level, the exogeneity assumption is more acceptable. A potential problem at the macroeconomic level, may be that both business and government expenditure could be influenced by common factors, which would bias the estimated relationship. Two factors are likely to be important. First, changes in the business cycle affect the financial constraints of government and business. To account for this problem, one can take GDP growth as an explanatory variable for business funded R&D. Second, changes in the cost of R&D may affect both sectors. For instance, the price of specialized inputs or the wages of researchers may increase when government expands its spending, leading to a growth in business spending that is only nominal in character[142].

---

[140] Van Pottelsberghe & Guellec (2001).

[141] It is only in later work on additionality (e.g. Buisseret et al. (1995)) that the additionality concept was further refined. Input and output additionality do not capture a whole range of intermediate results, which researchers started to call behavioural (see above), process or indirect additionality. Regardless the definition of this kind of additionality, these researchers pointed to the change in "activities" that a company deploys because of performing or having performed an R&D project or a series of R&D projects, financed with public money that would not have occurred without this specific support.

[142] Van Pottelsberghe & Guellec (2001). In many occasions it is useful to study whether there are differences between small and large firms. In an interview study of Norwegian manufacturing firms, Hervik and Waago (1997) find support for the hypothesis that large firms, having a portfolio of projects, will seek to obtain public support for those projects they have already decided to undertake, whereas small firms, being

Main Conclusions on the Impact of Subsidies

A very large number of studies exist on the effects of public R&D subsidies which were reviewed for the purposes of this report. Economists continue the tradition pioneered by the research of Blank and Stigler (1957), and examine a variety of data for signs as to whether the relationship between public and private R&D investments is on balance characterized by "complementarity", or by "substitution". The question: "Is public R&D spending complementary and thus *additional* to private R&D spending or does it substitute for and tends to *crowd out* private R&D?" is unfortunately a difficult one to answer, as the results which have been obtained are not **all** in the same direction. Several recent econometric studies, for example, document positive, statistically significant effects via the stimulation of private R&D investment by publicly funded additions to the stock of scientific knowledge[143]. The same might be said regarding a considerably more extensive body of historical case studies, detailing the influence of government-sponsored research programs and projects on commercial technological innovation[144]. Undoubtedly, however, while many studies in this area have been able to support claims of positive spillovers from public to private expenditures, there are also investigations mainly at the firm-level that arrive at the conclusion of a substitute relationship.

The econometric results obtained from careful studies at both the micro- and macro-levels tend to be running in favour of findings of *complementarity* between public and private R&D investments. However this should not be considered as a definite conclusion, as it does not constitute a result derived from a formal statistical "meta-analysis". The fact that the ability of the econometricians to impose *ex post* statistical controls varies widely among these studies, in combination with the multiplicity of the approaches in the literature and the consequent lack of immediate comparability between studies which are conducted at differing levels of aggregation, distributed over differing time periods, and across a variety of scientific and technological fields, makes it very difficult to weigh up and aggregate the available data and arrive at a definitive empirical conclusion regarding the sign and the magnitude of the relationship between public and private R&D[145].

Weighting carefully the evidence, it would seem fair to say that most economists would probably support the notion that subsidies are effective in inducing firms to invest into R&D though the effect may not always be large (that means that in their

less diversified and possibly more liquidity constrained, will find subsidies with a matching grant claim to be a stimulus making increased R&D investments possible. However, according to Klette and Moen (1998), it is difficult to find support for this hypothesis in their data. The only business units having some degree of additionality, approximately 25 percent, associated with R&D subsidies, are the large ones. For small units there is neither crowding out, nor additionality, whereas for medium size units the point estimate indicates about 50 percent crowding out. This finding might be rationalized by taking account of monitoring costs. Large firms are likely to be monitored more closely by the government, as they receive large grants and are well known "regular customers". If these firms apply for projects which are obviously profitable without subsidies, the governmental agencies might see through it, and they can even lose credibility with respect to future applications. This may explain why we do not find crowding out for these firms.

143 That, at least, is the presumptive interpretation of the results reported by Jaffe (1989), Adams (1990), and Toole (1999).

144 Among recent, sophisticated contributions to this literature, see Link and Scott (1998), and National Research Council (1999).

145 This is a summary of the conclusions reached by the extensive survey undertaken by David et.al. (1999) and is supported by more recent findings.

absence, projects could be carried out, although at a smaller size). Surveys have indicated that almost all firm sizes exhibit complementarities though to a different degree. It is the smallest and the largest firms which exhibit the highest leverage while the medium sized firms show only small additionality[146] .

.

The table below, which is based on the survey by David, Hall and Toole (1999), presents a summary distribution of econometric studies of the relationship between public and private R&D investment:

	Studies reporting "net" substitution	**Total number of studies**
Level of aggregation: Firm and Lower [a]		
Number of studies surveyed	9	19
Based on U.S. data only	7	12
Based on other countries' data	2	7
Level of aggregation: Industry and Higher [b]		
Number of studies surveyed	2	14
Based on U.S. data only	2	9
Based on other countries' data	0	5
All levels of aggregation	11	33

Source: David P, Hall B, and Toole A (1999)
Notes:
a The findings in Toivanen & Nininen (1998) for large firms and small firms each are counted as a separate study.
b Adams (1998), and Toole (1999) are included here.

David, Hall and Toole (1999), indicate that exactly one third of the cases report that public R&D funding behaves as a substitute for private R&D investment while two thirds indicate that there is a complementary relationship. However, the substitute result is far more prevalent among the studies conducted at the line-of-business and firm level, than among those carried out at the industry and higher aggregation levels, where the relative frequency approaches one-half. As we have stressed firm – level econometric studies suffer from a number of shortcomings. A second pattern that stands out from the table is that whereas five-sixths of the studies based on data from countries other than the U.S. report overall complementarity, the corresponding proportion among those based purely on U.S. data is only four-sevenths. That has some bearing upon a third feature of interest in the table: the regional contrast in the findings that emerges within the group of studies conducted at and below the level of the firm. Here one sees a marked difference between the distribution of the U.S.-based findings and the much higher relative frequency with which complementarity is reported by analysts working exclusively from U.S. evidence[147]. As the authors conclude, c*omplementarity appears more prevalent, and substitution effects all but vanish, among the subgroup of studies that have investigated this relationship at the industry and national economy levels, indicated strong positive spillover effects of subsidies.*

[146] Streicher G., Schibany A., and Gretzmacher N. (2004)
[147] It may well be that this latter contrast is in part reflecting underlying differences between the character of the U.S. federal R&D contracts and awards, and the purposes and terms of the more recent European government programs of funding for industrial R&D.

Recent non-econometric, qualitative evidence addressing the issue of additionality in all its dimensions also points to substantial complementarity effects. For example, Clarysse B, Bilsen V, Steurs G, Larosse J, (2004)*[148]*, examined the effectiveness of public R&D grants using a Questionnaire based survey[149] and found strong evidence of behavioural additionality (mainly for SMEs) as well as input and/or output additionality for all groups of firms. One of their more interesting results was that subsidies caused firms to undertake higher risk research than would otherwise be the case and increased their ability to network with other firms and/or PROs.

3. The Impact of Fiscal Incentives

Fiscal measures for R&D investment aim to stimulate the level of business R&D by reducing the tax burden of companies in proportion to the amount of R&D undertaken[150]. Tax incentives seem a natural policy tool for a market-oriented government wanting to increase R&D expenditures[151]. Firms decide where and how to spend their R&D rather than have it determined through a bureaucratic central authority. However, many economists express their concerns about the effectiveness of fiscal incentives in increasing private research efforts. These concerns are related to the relatively high costs of fiscal incentives to government without exactly knowing the additional amount of R&D generated by the incentives[152].

Many academic and governmental studies on the impact of fiscal incentives were undertaken over the last two decades both at the aggregate macroeconomic level and at the microeconomic level[153]. Almost all the results of these studies indicate that a decline in the cost of performing R&D generates additional R&D investments implying that fiscal measures targeting business R&D stimulate the total amount of R&D undertaken as they reduce the price of performing research. However, in many cases the elasticity found is relatively low[154]. The enormous diversity in the data sources, the methodology, the time periods and the scope used in the different studies makes difficult the comparison of the different results and hinders the inference of strong conclusions as to the general effectiveness of tax incentives. Also, generalising

[148] Clarysse B, Bilsen V, Steurs G, Larosse J, (2004).

[149] This happened because a first IWT project in 1999, using econometric techniques to evaluate the additionality on R&D expenditures pointed out that these quantitative results were not conclusive without some qualitative research by means of interviews.

[150] Van Pottelsberghe B, Nysten S and Megally E (2003).

[151] Several countries have introduced or extended fiscal instruments to support R&D. Fiscal incentives for R&D can be designed in many different ways, using corporation income tax, the company's share of wage tax (and associated social security premiums), or personal income tax regimes as a basis. Comparing the current schemes in operation in the world, we can distinguish many differences in their basic design.

[152] See: European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Fiscal Measures", EC

[153] An extensive review is provided in the extended version of this report. Here we mention Hall and van Reenen (1999), and Bloom N, Griffith R and Van Reenen J (2000), where an econometric model of R&D investment is estimated using a panel data on tax changes and R&D spending in nine OECD countries over a nineteen year period. The authors find evidence that tax incentives are effective in increasing R&D intensity. The econometric analysis suggests that tax changes significantly affect the level of R&D even after controlling for demand, country-specific fixed effects and word macro-economic shocks. The impact elasticity is not large (just over -0.1), but over the long-run may be more substantial (about unity in absolute magnitude). See also Van Pottelsberghe B, Nysten S and Megally E (2003).

[154] European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Fiscal Measures", EC

results obtained from using the data on one country to other countries can be misleading[155]. It has to be noticed that more satisfying answers as to the effectiveness of tax incentives can be found in the results of econometric studies which can be carried out on a microeconomic level-the most common-or on a macroeconomic level and show a negative price-elasticity for R&D expenditure.

Should one conclude then that R&D tax credits are desirable? Unfortunately, tax incentive schemes are not always evaluated either regularly or systematically by the responsible government departments or by external experts commissioned to undertake the evaluation. As a matter of fact, evaluations that are made publicly available are scarce; therefore one should be very careful before entering into any definite conclusions and take into account several other elements which would have to enter a cost-benefit analysis in addition to the elasticity of R&D[156]. However, in the absence of extensive evaluation studies, and taking into account the methodological difficulties attached to many of the econometric studies we can say that fiscal incentives stimulate business R&D. The few tentative evaluations show a positive, but moderate level of additionality. Nevertheless, the substantial amount of potential externalities (R&D spillovers) would strengthen the positive impact of tax credit[157].

4. Government Support for Collaborative R&D

Co-operative R&D has been widely celebrated as a means of promoting private R&D, and some see it as a major tool for enhancing industry competitiveness[158] (see also Parts I.A and II above). Governments emphasize the need to improve the transfer of know-how throughout the innovation system. One of the main issues in this context is collaboration between science and industry to strengthen the national innovation capabilities. In most OECD countries public measures are directed to bring private organizations and public research institutions closer together, providing researchers with skills and incentives to take their ideas to the market (cf. OECD, 2002)[159].

As noted by Sakakibara (1997), there are several possible approaches for the evaluation of government-sponsored R&D consortia[160]. An econometric analysis can be used to identify quantitative effects of R&D consortia. It is important to note that R&D consortia are only one of many factors determining the level and intensity of private R&D. The level of private R&D spending can be affected by many causes, including demand conditions and the technological opportunities faced by companies.

---

[155]There are few econometric studies outside the U.S. Recent exceptions include Dagenais, Mohnen and Thierrenen (1997) and Bernstein (1986, 1998) for Canada; Asmussen and Berriot (1993) for France and Australian Bureau of Industry Economics (1993) for Australia. They also tend to find larger elasticities. For a survey see Hall and Van Reenen (1999).

[156] Bloom N, Griffith R and Van Reenen J (2000). First, there are the administrative costs of monitoring the credit system. Second, there are many potentially perverse incentives induced by the design of different credit systems which could cause distortions to economic activity. Third, it is not obvious in a world of international spillovers that a country would not be better off free-riding on the R&D efforts of other countries rather than attempting to subsidize innovation itself.

[157] Sawyer, A., (2004).

[158] Sakakibara, (1997).

[159] Czarnitzki, D., and Fier, A., (2004).

[160] Success can be measured as a project's achievements relative to its intended goals. Possible goals include broad ones such as stimulating a nation's basic research, increasing spillover effects of R&D consortia among participants or to non-participants, and improving the foundations of a nation's industrial competitiveness. More specific goals can be set for each project, such as technological goals or commercialisation goals (Sakakibara. 1997).

It is therefore important to control for other determinants of R&D intensity to isolate the effect of R&D consortia.

Sakakibara (1997) points out that there are many case studies (for example, Katz and Ordover, 1990; Fransman, 1990; Murphy, 1991; Ouchi and Bolton, 1988; Dunning and Robson, 1988), but most treatments have been based on anecdotal evidence, or on the accounts of a few highly publicised co-operative R&D projects, namely MCC, SEMATECH in the US, ESPRIT in Europe, or the VLSI Project and the Fifth-Generation Computer Project in Japan. A deeper understanding of co-operative R&D requires a more systematic, cross sectional analysis. He concludes that co-operative R&D has been examined empirically by only a few studies and comprehensive empirical research is almost non-existent. Most treatments have been based on case studies or on the account of a few highly publicized co-operative R&D projects.

Sakakibara (2001) analyzed Japanese Government sponsored R&D consortia over 13 years and found evidence supporting the thesis that spillover effects occur. The magnitude of the effect of the participation in an R&D consortium on firm R&D expenditures is found to be nine percent, on average. Branstetter/Sakakibara (2002) examine the impact of government sponsored research consortia on the research productivity in Japan by measuring their patenting activities over time. They find evidence that participants of research consortia tend to increase their patenting after entering a consortium, which is interpreted as evidence for spillovers. The marginal increase of participants' patenting in targeted technologies, relatively to the control firms, is large and statistically significant[161]. More specifically, Sakakibara (1997)[162], used a questionnaire analysis[163] as an effective tool in this respect. A large number of government-sponsored R&D consortia were set up between 1959 and 1992, of which 237 are included in the data set. 1171 companies participated in these consortia during this period and many were involved in multiple projects. Inclusion of the multiple projects yields a data set with 3.021 company-project pairs[164]. Regarding the effects of R&D consortia on private R&D investment, it was found that if there was no co-operative R&D project, private projects would have been conducted at approximately 34 per cent of the scale of the actual ones – R&D consortia accelerated private R&D by three years[165]. To see how the R&D consortia have affected R&D spending, companies were asked how much of their own money was spent on R&D related to the consortia project. According to the results, on average, firms undertook private R&D spending equal to more than 87% of the government's budget allocated

---

[161] Czarnitzki, D., and Fier, A., (2004).
[162] Sakakibara, (1997).
[163] A questionnaire analysis is effective in evaluating the managerial perspective, including the motives for consortia participation and consortia design. This methodology facilitates the analysis of perceived overall successes, including the direct success of project outcomes and the general contributions of the project (Sakakibara, 1997).
[164] This data set was collected from each Ministry through direct contacts after examining a wide range of government White Papers and other government publications, and is as close as possible to an exhaustive list of all the government-sponsored R&D consortia in Japan (Sakakibara, 1997).
[165] One might argue that respondents have an incentive to report a smaller R&D scale than that which would have actually occurred in the absence of the co-operative project, in order to demonstrate the necessity of government incentives. The respondents, however, are R&D managers who do not necessarily negotiate directly with the government. Nor would the respondents expect their questionnaire responses to directly affect governmental decision making. Therefore, it is reasonable to assume that the potential for biased responses is minimal (Sakakibara, 1997).

to that firm. So one could conclude that government-sponsored co-operative R&D serves as a complement, rather than a substitute, to private R&D.

In another very recent article, Czarnitzki and Fier (2004)[166], try to shed some light on the question of the return to supporting RJVs: What are the benefits of public incentives for R&D collaborations in terms of innovative output? The main issue of their analysis has been to distinguish the patenting behavior of three different groups of firms: (i) non-collaborating companies, (ii) collaborating firms which are involved in publicly funded R&D consortia, (iii) firms involved in privately financed R&D collaborations. They examined whether R&D collaborations lead to higher research output. This would support the hypothesis that knowledge flows among partners emerge and positive spillovers are generated. Moreover, they investigated if publicly funded firm collaborations differ from collaborations which are privately financed.

Some of the most interesting conclusions were that supporting the formation of RJVs (e.g by exempting these agreements from Competition Policy legislation) is good because it improves innovation (proxied by patenting) and subsidizing RJVs is even better, as RJVs are more innovative when they are subsidized than when they are not[167]. Overall, the econometric analysis suggests that the predictions made about the effect of participation in research consortia on R&D performance found support in the data. Namely:

- participation in R&D consortia tends to be associated with higher levels of R&D spending of participating firms;
- participation in R&D consortia also seems to raise the research productivity of participating firms;
- the results suggest that at least one channel through which consortia have these positive effects may be through effectively augmenting knowledge spillovers.

5. The Impact of Guarantees

In a recent report[168], an attempt was made to examine how guarantee mechanisms and other risk sharing mechanisms associated to loans or equity can contribute more widely and more effectively to stimulating private investment in research, taking into account differences in national conditions. Guarantees are financial instruments which the public sector can use to catalyse investment in R&D via public sector bodies offering to cover or share part of the risk associated with the investment, thus encouraging potential investors to provide finance to R&D performers. The major types of guarantee instruments are: loan guarantees and equity guarantees. A *loan guarantee* is the promise of the guarantor to pay the loan if the borrower cannot or does not repay. As any losses have to be covered by the public budget, subsidised loan guarantees can be considered a form of State aid. Such public loan guarantee schemes are frequently used to help companies – primarily SMEs – with a low degree of creditworthiness to gain access to long-term loans. Loan guarantees can thus be used as an instrument to facilitate the loan financing of R&D-intensive companies,

[166] Czarnitzki and Fier (2004).

[167] This study is a very useful addition to the literature as it undertakes econometric analysis carefully taking into account: (i) both patent applications and granted patents as measures of innovation (ii) all the important control variables and (iii) the possibility of self-selection bias. Unfortunately, the study does not treat the important issue of "additionality" in a totally satisfactory way as it cannot, account for a possible "displacement effect".

[168] "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Guarantee Mechanisms", EC, 2003

since these are often considered to present a high or poorly understood credit risk. *Equity guarantees* cover some of the risks of failure (loss risks) associated with equity investments. They have been developed in some EU countries in recent years to support the equity financing of small, young and new technology based firms (NTBFs) by Venture Capital (VC) funds. They encourage investment by protecting the invested equity capital against some of the high risks associated with financing NTBFs. There are a number of important framework conditions influencing the effectiveness of guarantees. These include State aid regulations; the state of development of the financial system, including its regulatory system; macroeconomic policy; and the general climate towards entrepreneurship.

There are relatively few evaluation studies on the impact of guarantee schemes in developed countries, and those that do exist, focus on additionality in areas like job creation rather than R&D. Statements about the potential contribution of guarantees to R&D investment should therefore be treated with caution[169]. In particular, estimating the potential impact of an increase in guarantees on R&D investment in Europe is a hazardous exercise, given the shortage of detailed evaluation studies on the additionality achieved by guarantee programmes in general and on R&D in particular. Nevertheless it appears safe to say that the impact of an expansion in horizontal loan guarantee programmes on R&D investment would be small due to the small proportion of R&D intensive companies participating in such schemes. However, greater benefits could be expected from equity guarantee and innovation loan guarantee programmes due to the nature of the investment projects supported. These two types of guarantee programmes could help reduce the R&D investment gap relative to the US with respect to NTBFs and established SMEs. The Risk Capital Expert Group has estimated that measures supporting the development of venture capital in Europe could help boost R&D investment by between € 2-5 billion, a significant proportion of the overall € 100 billion gap relative to the US. Guarantee mechanisms could be a significant instrument contributing to this increase.

6. Factors that influence the effectiveness of State aid as a policy instrument

Friederiszick, Roller and Neven (2004), using data from EU MSs over the last 20 years to investigate the effectiveness of State aid[170], obtained the following findings:

- ❖ An elasticity of State aid of 0,092 was found. Moreover, the impact of R&D State aid on private R&D is statistically significant. Specifically, it was found that 1% increase in per capita R&D State aid over the last 5 years leads to a 0,092% increase in privately funded BERD per capita.
- ❖ The above implies that State aid on R&D exhibits diminishing returns: the more State aid is granted the lower its effectiveness in raising private investment in R&D[171].
- ❖ There is considerable interdependence of aid instruments. There is a positive complementarity between R&D and SME aid. In other words, the higher the level of SME aid, the more effective R&D aid becomes in terms of stimulating private R&D. The reverse is also true. By contrast there is no complementarity between R&D aid and regional aid. The fact that regional aid

[169] A number of schemes are reviewed in the extended version of the report.

[170] They used 3 types of measurement strategies to investigate the effectiveness of aid: indicators, correlations, and regression analysis.

[171] The elasticity becomes larger with more control variables. For results on patenting see their Annex.

is not complementary also implies that countries with higher levels of regional aid tend to have lower R&D effectiveness.

- R&D State aid in the form of subsidies is more effective than R&D aid granted through tax relief or equity.
- With regard to other variables, both public R&D and general public investment are important for private R&D. In terms of explaining the effectiveness of R&D aid, both public R&D and general public investment are complementary to R&D State aid.

7. Main Conclusions

1. The promotion of RJVs has been one of the major policy instruments used by the Commission for the last two decades, in its attempt to raise European R&D. The most recent empirical studies indicate that the formation of RJVs is efficient, as it tends to be associated with higher levels of R&D spending of the participating firms and raises their research productivity. One of the most interesting results is that government-sponsored co-operative R&D serves as a complement, rather than a substitute to private R&D and that RJVs are more innovative when they are subsidised than when they are not.
2. A very large number of studies have been undertaken in order to examine the relationship between public and private R&D investment (in the form of subsidies). Despite the heterogeneity of the empirical models used, which makes any comparison exercise hazardous, the balance seems to tilt towards the recognition of a complementary relation. Complementarity appears more prevalent, and substitution effects all but vanish, among the subgroup of studies that have investigated this relationship at the industry and national economy levels, indicated strong positive spillover effects of subsidies.
3. At the same time, many studies on the impact of fiscal incentives, both at the macroeconomic and the microeconomic level, indicate that a decline in the cost of performing R&D generates additional R&D investments implying that this type of financial measure stimulates the total amount of R&D undertaken.
4. Unfortunately, in the case of guarantee measures there are very few studies and consultant evaluations suggesting that agencies are reluctant to expose the performance of their schemes to external scrutiny. This lack of formal evaluation studies makes it difficult to make predictions about their probable impact.
5. From all the preceding analysis we can conclude that available empirical evidence suggests that State aid does stimulate private R&D. Since there is not only one type of financial instrument aimed at fostering business R&D, there is a strong need for co-ordination between the various institutions and ministries involved in the financing of business R&D. What constitutes an “effective” mix of direct (by form of subsidies) and indirect measures (by form of fiscal incentives) depends, to a high degree, on the specific conditions in member states, i.e. on framework conditions and, in particular, on the state of the respective national innovation system, its institutions and their strategies. There is evidence that the effectiveness of one instrument depends on the use of other instruments in the system of public support to R&D. Unfortunately, despite the fact that it is essential, at least at present co-ordination of instruments seems to be insufficient in many countries.

PART VI

A Policymaker's Perspectives on State aid: Analysis of a Questionnaire Survey

1. Introduction

As part of this study, a questionnaire was sent to policy makers at national and regional levels across Europe.[172] The aim of the survey was to throw more light on a number of issues relating to EU State aid for R&D, specifically:

- The leverage effects of existing R&D support schemes;
- The indirect leverage effects of innovation support schemes on R&D investment levels;
- Assessments of the effectiveness of State aid ;
- Appropriate categories and ceilings for R&D State aid ;
- Increased ceilings in special circumstances;
- The range of eligible costs for R&D State aid ;
- The boundary between R&D and Innovation;
- R&D Support to Public Research Organisations (PROs);
- The efficiency of R&D State aid procedures;
- The efficiency of Innovation-related procedures.

In all, there were responses from 17 national ministries or agencies in 16 countries and 7 regional authorities in 3 countries. Summaries of the responses to all the questions are organised into distinct sections addressing the issues outlined above. An expanded summary of the responses is presented in the APPENDIX to Part VI.[173]

2. R&D Support Schemes

Almost all countries responding to the survey provided examples of R&D support schemes demonstrating high leverage on private sector R&D investment levels. They include a broad range of both direct measures and fiscal measures, with many of them promoting collaboration and networking between a wide variety of R&D and innovation actors. It was also notable that the distinction between 'R&D' and 'Innovation' support mechanisms had been deliberately blurred in a limited number of countries, particularly those with relatively advanced R&D and innovation systems.

There was little consistency in the presentation of data on the leverage associated with different types of scheme, making it impossible to say anything definitive about either average leverage levels or the range spanned. On occasion, leverage was expressed in terms of the aid intensity ceilings for **individual organisations** (leading, for example, to 1:1 public/private ratios for the support of industrial research in private sector organisations). In other instances, estimates of leverage were given in terms of direct expenditure by the public and private sectors across whole **programmes**. For example, in schemes such as collaborative R&D programmes, which often involve 100% support for academic partners and 50% support for industrial partners, leverage ratios of 1:<1 were not uncommon. In the majority of cases, however, it was not obvious how leverage had been calculated. In particular, it was often unclear whether ratios expressed in the form 1:>1 represented the relative proportions of **direct** expenditures within initiatives or more sophisticated estimates of additional or **indirect** R&D stimulated over time.

[172] A similar questionnaire, appropriately modified, was sent to companies and public research organisations. To this, however, there were only three responses (from Philips (Netherlands), SAP Business Development (Germany) and UNICE). These were not analysed separately, but points contained within them were considered in the development of other parts of the study.

[173] The individual responses of all countries and regions were also made available to the Commission services.

3. Innovation Support Schemes

Many countries responding to the survey also provided examples of schemes designed to support innovation more broadly. Initiatives deemed to have high leverage effects on private sector R&D investment levels included:

- Awareness schemes aimed at increasing awareness of the usefulness of innovation (and R&D) amongst opinion leaders, academia, entrepreneurs and the wider public;
- Audit schemes involving diagnostic tools for assessing R&D and innovation capacities;
- R&D partner search schemes;
- Schemes subsidising the involvement of science and engineering graduates in low-tech firms;
- Support schemes for development projects within young enterprises spending more than 15% of their total expenditure on R&D;
- Schemes involving grant or loan support for the direct development of commercial products and services;
- Incubator schemes and finance for start-ups;
- Technology transfer schemes;
- Cluster schemes involving support for a range of R&D, innovation and networking activities in defined geographic regions or technological fields

Most countries recognised that programmes such as these would have indirect effects on R&D levels and that, consequently, estimates of leverage were difficult to make.

4. Assessing the Effectiveness of State aid

There was an overwhelming consensus that the overall effectiveness of R&D State aid should be judged not only in terms of its leveraging effect on private sector R&D levels – as raising R&D intensity was in itself just a means to an end – but also on its potential to influence other factors such as increased innovation and enhanced competitiveness. To paraphrase one country's response: "*Ex ante* evaluations should take into account effects on the diffusion of knowledge, impacts on collaboration and also whether the eligible costs cover the activities necessary to maximise likely impacts. Evaluating diffusion effects and behavioural changes (e.g. with respect to R&D and collaboration) should also be included in *ex post* effectiveness assessments. Experience so far has shown that underestimating the role of other prerequisites for innovation and too narrow a focus on technological elements will lead to a situation where projects will succeed in an R&D sense but fail commercially."

Suggestions for factors to be taken into account in assessing State aid for R&D included its direct and spillover impacts on:

- Private sector R&D levels, capacities and modes of implementation;
- Public sector R&D levels, capacities and modes of implementation;
- Entry into new scientific and technological fields;
- Degree of collaboration and networking stimulated;
- SME involvement in R&D and innovation activities;
- R&D intensity and innovative activities in low-tech sectors;
- Innovation activities *per se*, including the introduction of new products and services and improved technology transfer;
- Productivity;

- Competitiveness;
- Growth;
- Entry into new markets;
- Skills, employment and human capital development;
- Sustainability and the environment.

5. Ex Ante Assessments of R&D State aid

When quizzed about the relative importance of the criteria used to anticipate the leverage of State aid on private sector R&D, respondents generally regarded the level of risk associated with the R&D as the most important, followed by the additionality associated with the proposed measure. Most countries and regions, however, regarded a range of criteria as important, with considerable diversity between countries in terms of the relative levels of importance accorded to different criteria. One country also pointed out that the criteria deemed important vary on a case-by-case basis, which in turn highlights the fact that the level of potential leverage associated with any one criterion itself determines the importance of that criterion in a given context.
Concerning the criteria used to assess the potential of State aid to lead to enhanced innovation and competitiveness, the potential for spillover effects was cited most frequently by countries as an important criterion, though again most countries recognised the importance of a diverse range of criteria. This was even more marked at a regional level, where regional authorities gave relatively equal weight to the potential for spillovers, the strategic importance of the technical areas targeted and the additionality associated with the measures contemplated.

6. Ex Post Assessments of R&D State aid

Ex post assessments of the effectiveness of State aid were commonplace in most countries and regions, with only four out of sixteen countries and two out of six regions stating that assessments of this nature were not conducted. Most assessments took place at a programme level. These were embedded within comprehensive policy and programme evaluation systems in some countries, but were conducted on a more *ad hoc* basis in others. There were indications that more systematic assessment schemes are evolving in many quarters.

7. State aid R&D Categories and Ceilings

Currently State aid ceilings vary for different categories of R&D activity and a debate exists over the definition of these categories and the level of the ceilings within them. Amongst respondents, however, there was remarkably little pressure for overt changes in either the ceilings or the categories used to define R&D activity. Overall, nine out of 15 countries were content with the existing categories and ceilings, five suggested changes to the ceiling for pre-competitive development (two suggesting a rise to 50%, one to a ceiling ≥ 40%, and two to 35%), and only two countries suggested changes to the ceiling for industrial research, with one advocating raising the ceiling to 70% and the other lowering it to a figure ≥ 40%.

i. Analysis of Responses for Fifteen Countries

Category	Current Ceiling for State aid	Suggested Ceiling

	(as a % of eligible cost)	
Fundamental research	100%	No change - 15 countries
Industrial research	50%	No change - 13 countries ≥40% - 1 country 70% - 1 country
Pre-competitive development	25%	No change - 10 countries 35% - 2 countries ≥40% - 1 country 50% - 2 countries
Patent protections	Same % as that for the research leading to it	No change - 14 countries 50% flat rate – 1 country

Of the seven regions responding to the questionnaire, three were in favour of the status quo, four suggested raising the ceiling for pre-competitive development (to 30-50%), and one suggested raising the ceiling for industrial research to 55%.

ii. Analysis of Responses for Seven Regions

Category	Current Ceiling for State aid (as a % of eligible cost)	Suggested Ceiling
Fundamental research	100%	No change – 7 regions
Industrial research	50%	No change – 6 regions 55% - 1 region
Pre-competitive development	25%	No change – 3 regions 30% - 2 regions 40% - 1 region 50% - 1 region
Patent protections	Same % as that for the research leading to it	No change – 6 regions 40/55/100% – 1 country

Only one regional and two national administrations suggested abandoning the three-tier categorisation system currently in use and adopting a two-tier system, specifically one which combines the categories of industrial research and pre-competitive development into a new category with a ceiling of ≥ 40% (one country) or 50% (one country and one region). One country also suggested a 50% ceiling for pre-competitive development, but called for the industrial research ceiling to rise to 70%.

8. Increased Ceilings

Just as there was little pressure for overt changes in the baseline State aid ceilings for the three main categories of R&D activity, there was a similar lack of enthusiasm in most countries and regions for modifications to the ceilings applicable to 'special circumstances'.[174] This was particularly so for changes to the ceilings for industrial

[174] At present, there are higher ceilings for SMEs (60% for industrial Research; 35% for Pre-competitive Development); for Objective 1 Regions (60% for industrial Research; 35% for Pre-competitive Development); for Objective 2 Regions (55% for industrial Research; 30% for Pre-competitive Development); for programmes in line with R&D Framework Programme Objectives (65% for industrial Research; 45% for Pre-competitive

research, but resistance to change was only slightly less marked for those changes affecting the ceilings for pre-competitive development. Concerning R&D aid in Objective 1 and Objective 2 regions, for example, 12 countries out of 16 were happy with the existing ceilings for industrial research, as were 6 regions out of 7. For pre-competitive development, 11 out of 16 countries and 5 out of 7 regions were satisfied with the status quo.

There was also little unanimity amongst the minority suggesting changes. For the special case of SMEs, for example, for which the pressure for change was greatest, one country suggested that special ceilings were not needed at all; three countries suggested different ceilings for SMEs in different size categories; and five countries suggested raising the ceilings of one or both of the categories of industrial and pre-competitive research (to 70% and 75% for industrial research and to 45% and 50% for pre-competitive research). Four out of seven regions also suggested that the ceiling for pre-competitive development for SMEs should rise to either 40% or 50%.

9. Eligible Costs

The current framework for R&D State aid classifies eligible costs under five categories covering personnel, equipment, consultancy, overheads and other operating costs. Five countries considered the categories adequate and easy to work with and had no recommendations for change. Satisfaction levels within the remaining countries and regions were also high, though some minor changes were suggested. Four countries and one region, for example, were in favour of using the FP6 cost approach or aligning with the approach to be used in FP7, and two sought changes to the definition of personnel costs (by adding in the costs of administrative staff). Another country noted that difficulties arose when costs had to be apportioned between the R&D projects supported by state aid and other activities undertaken by firms, and that this was especially difficult with software research and development. Generally, however, the plea was for greater transparency, simplification and flexibility, especially in terms of easing the burden on SMEs and start-ups. One country, for example, specifically resisted any changes likely to constrain the access of SMEs with limited R&D personnel to external consultancy assistance.

10. R&D and Innovation

R&D and Innovation-related activities are treated separately as far as State aid is concerned and there is a current debate about the advisability of maintaining this separation. Countries and regions fell into three camps, though the broad swell of opinion was that it was time for a change. Four countries and three regions felt that the existing separation and definitions were adequate and should be kept; another group of five countries and one region were in favour of modest revisions involving the inclusion of some innovation-related activities within the State aid framework for R&D. The remaining members of a group of six countries and four regions were in favour of dropping the separation between R&D and innovation, but provided few clues as to how this might be done (apart from applying the same ceiling as pre-competitive research to all innovation activities), or how to differentiate innovation from, for example, other investment-related activity.

Development); for programmes in line with R&D Framework Programme Objectives and supportive of cross-border cooperation (75% for industrial Research; 50% for Pre-competitive Development); and for special cases of cooperation and dissemination (60% for industrial Research; 35% for Pre-competitive Development).

One suggestion for an extension of the current State aid framework to cover some innovation-related activities closely linked to R&D (while excluding other activities either not eligible for State aid or eligible for aid provided within other frameworks) involved adopting a definition of allowable activities in line with the current Sixth Framework Programme financial guidelines, which state: "Consortia are encouraged to include innovation-related activities in their project, and such activities will be supported by EC funding under the same conditions as R&D activities… Typical examples of innovation-related costs include: Intellectual property protection, dissemination activities, studies on socio-economic aspects and activities promoting the exploitation of the results." FP6 also encourages training activities, consortia management activities and demonstration activities, which may include "prototype design and assembly, test bench validation, large infrastructure use for testing prototypes and pre-certification for testing purpose."

Concerning potential modifications to the State aid frameworks for R&D and Innovation, the survey asked whether there should be special provisions for:

- Support measures aimed at the creation of strong networks and clusters of R&D and innovation actors;
- Support measures aimed at the creation of high tech start-ups;
- Support measures for large-scale public-private partnerships and technology platforms;
- Technology procurement (whereby the State procures goods and services necessitating further R&D prior to their commercial availability).

In terms of networks and clusters, many respondents simply affirmed their belief in the importance of network-oriented support measures. Amongst those who did interpret the question in terms of the need for special provisions within the R&D State aid framework, there was support for the existence of these provisions but few solid proposals concerning the form they should take. Exceptions included recommendations for a higher ceiling (e.g. 75%) and another suggestion that all support for R&D and innovation-related networking be treated under the State aid framework for R&D, rather than under other frameworks (e.g. regional aid; SME aid).

Concerning support measures aimed at the creation of high tech start-ups, most respondents were in favour of their inclusion. Suggestions included:

- Increased ceilings within the R&D framework for R&D projects conducted by such enterprises;
- Reformulation of the State aid framework for R&D to include investment aid for high tech start-ups, effectively removing such aid from the sphere of other State aid frameworks;
- Reformulation of the framework for Risk Capital to cope better with market failures in this area, including provision for higher and more flexible ceilings.

Respondents were divided on the issue of special provisions for large-scale public-private partnerships and technology platforms, with half or more in favour of special provisions, approximately a quarter against and a quarter undecided. Amongst those in favour, one noted that the intensity and absolute amount of State aid should relate to entire projects and not to individual participating enterprises, since it would be very difficult to estimate individual advantage. The same country also called for any new provisions to be coherent with those likely to apply within the Seventh Framework Programme. In contrast, another country in favour of special provisions favoured a separate block exemption regulation once the circumstances under which higher State aid would be possible had been defined.

There were few responses concerning the issue of technology procurement. Those that did respond recognised the role that procurement could play in fostering R&D and innovation, but were keen that it was not seen as State aid unless accompanied by open access to the results of the R&D.

11. R&D Support to Public Research Organisations (PROs)

The current rules governing support for R&D carried out by PROs on behalf of, or in collaboration with, industry specify that State aid is not involved when:

- PROs receive payment for the R&D services they perform;
- The firms involved pay all the R&D costs;
- All IPRs are allocated to the PROs and results not giving rise to IPRs are available for widespread dissemination;
- PROs are compensated for any IPRs resulting from projects and, once again, results not giving rise to IPRs are available for widespread dissemination.

The response to the survey indicated that about a third of the respondent countries and regions had experienced problems with these rules, with no problems reported in a further third and no response to this particular question from the remainder. The root of many of these problems was the growth in co-financing of activities within PROs by both public authorities and private companies; the resultant variable patterns of IPR ownership; and the consequent lack of clarity concerning the sphere of application of State aid rules. Two countries in particular noted that the current framework does not give any guidelines for dealing with non-exclusive user rights, and that it is also ambiguous concerning indirect State aid in the form of transferred IPR. There was thus an argument for new guidelines stating that State aid is not involved when non-exclusive rights to use intellectual property are transferred from public non-profit-making establishments to industrial participants in exchange for the partial funding of project costs. Moreover, there is also a case for a similar guideline specifying that State aid is not involved when non-exclusive rights to use IP are transferred from public non-profit-making establishments to industrial participants for less than full market price, on condition that other industrial enterprises are guaranteed the same type of access.

12. R&D State aid Procedures

The period taken to get agreement from DG Competition after initial notification typically ranged from 4-14 months, with the majority of notifications taking 6-9 months. On one occasion agreement had taken three years; on another it took18 months. Almost all countries and regions complained that the average period was too long, with some calling for it to be cut to 2-3 months. The main bottleneck, in the view of many, was the delay introduced when the Commission made a written request for more information – itself to be provided in written form. Respondents noted that this effectively added two months to the process and represented an inefficient form of communication and flow of information between the concerned parties. Suggested solutions included the setting of inviolable time limits for the process to be completed; replacing written responses to requests for information with meetings at which all relevant issues could be discussed and resolved; the allocation of more resources to the processing task within the Commission; and restricting notification only to those cases involving either large financial sums or likely to distort competition severely.

Only one instance of a proposed scheme having to be modified considerably was reported, with one other country reporting just modest changes. In the case affected severely, the changes imposed (the appointment of independent appraisers to assess the value of IPR and the contribution of companies to R&D projects), the national ministry concerned felt that the changes were burdensome and likely to have an adverse effect on cooperation between the companies and PROs in the proposed initiative. Severe modifications to proposed schemes were also reported in another country, but these involved Environmental and Risk Capital guidelines.

Just as severe modifications to schemes falling within the R&D framework were rare, only two countries had to abandon proposed schemes, and only two countries experienced major problems relating to existing schemes. A proposed scheme in one country was intended to support a particular class of enterprise, namely young companies less than 8 years old spending more than 15% of their total expenditure on R&D. This scheme had to be modified, however, as it did not comply with the conventional notion of support for R&D projects within the existing R&D framework.

Invocation of the additionality criterion for State aid only created a problem on isolated occasions for four countries, with other countries noting that its use was "a necessary discipline to ensure that aid is necessary and that it genuinely encourages R&D rather than simply reduces a company's overall costs". One country that had experienced difficulties noted that the quantification of additionality was a problem, especially when publicly-supported R&D projects formed only a small part of the R&D portfolios of large firms. It therefore called for greater reliance on qualitative rather than quantitative assessments. Another country, albeit one in which many large enterprises typically take part in publicly-supported R&D initiatives, was in favour of extending the assumption contained in Article 6.4 of the R&D framework to large firms, i.e. it called for the Commission to assume that aid to enterprises provided the necessary incentive irrespective of whether the enterprises were large firms or SMEs. Another country also called for a revision of this Article, though with greater caveats concerning large firms. In this instance, the Commission was asked to assume that aid to large firms provides a necessary incentive if the relevant R&D projects involve:

- Significant amounts of collaboration or networking;
- Fundamental research capable of widespread dissemination;
- Industrial research in strategically important areas.

In relation to the notification threshold of 25 million € for individual research projects, only one country reported that his threshold had caused problems – though only in terms of adding to the time taken to negotiate an agreement with the Commission concerning a proposed initiative. Some countries, however, did suggest that the threshold could safely be raised to, for example, 40 million €.

There were few positions taken on the issue of the efficiency and effectiveness of the application of State aid in specific sectors. One region and one country argued against any special consideration being given to specific sectors within a revised State aid framework for R&D. In contrast, another country called for the use of block exemptions for R&D in specific sectors; one region called for a higher ceiling for low R&D sectors; and one country argued that sectors critical to the advancement of 'sustainability' could be privileged. Yet another country, noted that aid could, and perhaps should, be limited in some sectors.

13. Innovation-related Procedures

There were few instances in which current Competition Policy had adversely affected innovation support schemes. In fact, only three countries reported problems. In one of them, a proposed business incubator scheme had to be abandoned when approval was not forthcoming, and pilot demonstrators for environmentally-friendly technologies also had to be either scaled down or abandoned. On occasion, problems also occurred as a consequence of the rigorous application of the indicative ceilings on tranche limits under the Risk Capital guidelines. In the second country reporting problems, the contents of a proposed innovation and technology funding scheme had to modified in line with acceptable definitions of the term 'innovation', and in the third country, problems arose in existing schemes because of the exclusion of aid for 'soft' or 'non-technological' innovation.

14. Conclusions

Even though there are many theoretical arguments for a reconfiguration of the categories used in the R&D State aid framework to differentiate between different types of R&D, there is little pressure amongst the policymaking community in the EU for a change in these categories or for a readjustment of the ceilings within them. Similarly, there is little enthusiasm for broadening the range of 'special circumstances' warranting higher ceilings, or for the modification of ceilings within existing categories denoting 'special circumstances'. In contrast, there is pressure for change at the boundary between R&D and innovation, with the boundary redrawn to allow some of the innovation-related activities closely linked to R&D to fall within the R&D State aid framework. There is little accord, however, concerning the ways in which the boundary could be redrawn or the activities which should be affected. There are also indications that changes will be needed to refine the State aid rules governing PROs given the changing nature of their interaction with the private sector. Some of the guidelines concerning the transfer of IPR and non-exclusive user rights from public to private sector bodies are in particular need of clarification.

At an operational level, the policymaking community is broadly satisfied with the classification scheme used to define eligible costs in the R&D State aid framework, though many recognise that there is always room for greater transparency, simplification and flexibility. There are also few complaints about the over zealous application of State aid rules, since few proposed initiatives have had either to be modified drastically or to be abandoned as a consequence of clashes with the current State aid regime. There is dissatisfaction, however, with the length of time it takes for initiatives to be rubber-stamped after they have been notified to the Commission.

Policymakers concur that the effectiveness of R&D State aid needs to be assessed in terms of both its leveraging effect on private sector R&D levels (with risk and additionality as important *ex ante* criteria in the choice of appropriate policy initiatives) and its downstream impact on variables such as innovation and competitiveness (both directly and indirectly via spillover effects). Assessments of both, however, are hindered by the wide variety of instruments used to support R&D and innovation; by the lack of any common guidelines for the definition and assessment of leverage; by the sheer range of factors which theoretically have to be taken into account in broad ranging impact assessments; and by the intractable nature of many of the problems relating to the assessment of causality and attribution.

PART VII

Main Conclusions and Recommendations

1. The role of State aid to R&D in the overall public R&D support context: statistical trends

- ***Since 2000, R&D aid has increased significantly in importance as a State aid category.*** It is now much more important relative to other forms of State aid and to VC investment having increased from €3.6 billion in 1992 to €5.2 billion in 2002, an increase of 44.4%, or from a share in total horizontal aid of 11,5% to 21%. The majority of MSs have followed this increasing direction. In UK and Germany, the amount of R&D aid granted since 1992 has increased by over 100%, while in France and Italy aid remained more or less constant.
- By far ***the most important instrument used to provide aid to R&D is that of grants (over 70%), its significant having increased over time,*** with the only country, UK, that was adopting tax exemptions on an equal basis having reduced its reliance on this instrument too.
- What emerges from our statistical analysis is that State aid to R&D still does not represent a significant factor in the overall R&D activity of the EU. This is true whether its significance is judged in terms of its size relative to the various R&D expenditure categories – see Section 3.5 of Part I.B - or when judged in terms of the relevance of State aid to R&D for closing the gap in business expenditure on R&D with EU's major competitors. ***A huge increase in its (2002) magnitude, requiring a much greater percentage increase per year than that achieved on average between 1992 and 2002 (4,5%) or even than that from 2000 to 2002 (11%) is necessary in order for State aid to R&D to make a significant contribution towards achieving the Barcelona objective*** (it should grow on average by 45% per year between 2003 and 2010 for the BERD gap between EU and USA to close). Of course, this calculation ignores that State aid may have a ***leverage effect*** on private R&D (indeed we show that it does in Part V) and, also, that for given R&D aid, a substantial ***improvement in Framework Conditions*** in the EU could also assist considerably in closing the gap, though the impact of improving these conditions on business expenditure on R&D is likely to be much more long-term. Finally, it is worth stressing here the ***potentially important role of general (e.g. tax) measures (not classified as State aid) towards closing the gap in business expenditure on R&D with EU's major competitors.***

2. The role and recent functional changes of public research establishments (PREs) and of their links to industry

General

- Over the 1990s, ***R&D performed by the higher education sector (HERD) increased steadily in the EU,*** while ***the share of HERD in GERD has remained approximately constant in EU (at about 20% in 2001)*** and Japan and declined in USA (to about 18%, from 14% in 1992).
- HERD's share in GERD is above EU average in Greece, Portugal, Italy, Austria, Spain and the Netherlands where it accounts for over 25%, below the EU average in Germany (16,5%) and France (about 19%) and close to EU average in UK (21,5%).
- Important is also the percentage of HERD financed by industry, as an indication of a pattern of increased university-firm interactions (often intending to promote commercialization of university research). ***The***

proportion of HERD funded by industry for EU has climbed from 5.9% (1992) but is still very small (6.7% in 2001).

- Concerning intramural government expenditure on R&D (GOVERD) as a percentage of GDP, in 2002, governments in the EU spent a larger share of GDP on intramural research (0.25%) than the US (0.24%) but lower than Japan (0.3%). During the 1990's, the three OECD regions experienced different trends. While for the US the share was largely stable over the period 1992–2002 (dropping from 0,26% to 0,24%), ***for the EU it showed a slight downward trend*** (from 0.31% to 0.25%). It dropped in France, Italy and most significantly in the United Kingdom. The reductions are due to a decrease in defence spending and transfer from public agencies to the private sector. Japan is the only large OECD country where R&D performed by the government sector increased after 1992, from 0.24% to 0.3% of GDP, as its laboratories benefited from science and technology policy initiatives over the decade.
- ***In 2001 the GOVERD share of GERD was about 13% in EU*** compared to 8% in USA and 9,5% in Japan. In the preceding decade the share declined in the EU (from about 16,5% in 1992) – indicating difficulties for PRIs in re-defining their position following the changes in the legal and regulatory framework and the new societal and/or governmental demands of R&D, and increased co-operation between various actors throughout the R&D system – while it stayed about the same (small decline) in US and increased slightly in Japan.
- Concerning the role of the business sector as a financier of R&D by PRIs, a growing share of funding by business would indicate their willingness to exploit public research, and that PRIs are willing to intensify co-operative activities with businesses and to commercialise their expertise. ***On average in the EU this is clearly not a prominent feature of the R&D system.*** The percentage has fluctuated in the decade prior to 2001 settling to 6.3% (from 5.6% in 1992 – but falling from a high 8% in 1999). However, it is worth noticing the much higher share of public R&D financed by the business sector in Netherlands (22%), Finland (15%), UK (13%) and Ireland (10%) and the relatively small percentage in Germany, 2.3%, falling from 3.4% in 1992.

Changes in the Institutional, Legal and Regulatory Environment of PREs

- It has been argued that the European innovation gap is due to insufficient and inefficient scientific and technological transfer mechanisms. While on the one hand, Europeans produce a large volume of new knowledge, the transformation of this knowledge into new products, processes and services is poor relative to Europe's main competitors. In an effort to improve cooperation, links and transfer mechanisms between EU PREs and industry, there has been substantial reorganization of Public Research Institutions (PRIs) and Higher Education Institutions (HEIs) in recent years.
- The EU has not advocated a regulation similar to the US Bayh-Dole Act to foster interaction between academia and the business community. However, at national level, many MSs, recognising the important role of Industry-Science Links (ISLs) in their innovation competence, launched similar kind of policies and changes in the legal and regulatory framework in the last two decades. This is especially the case of UK. It remains unclear which framework is preferable.

- ***Much of the focus of the reforms in the legal frameworks has been on the issue of transferring ownership of IP to the performing institution.*** However, in countries where the PREs have owned the IP, patenting activity by institutions has nevertheless been weak. Partly, the reason for this is that PREs have not had sufficient incentives, beyond legal requirements or institutional policies, to disclose, protect and actively commercialize IP.
- A direct consequence of policies to grant PREs title to inventions has been the creation of Technology Transfer Offices (TTOs). Their structure differs in different countries and, again, it is not possible to identify an optimal structure independent of the country concerned. ***One of the main challenges facing PREs, despite the assistance provided by governments, is to attract and retain the human resources to manage TTOs and interact with scientists.***
- ***Only five countries (Austria, the Netherlands, Italy, Sweden and the UK) report a change of status of PRIs as comprising privatisation***, in the period 1989–2001, covering a small number (32 out of 705) of laboratories in all.

Commercialization of Public Research and Public/Private Partnerships

- ***The long term viability of technology transfer operations remains an issue in most countries*** - though evidence from successful TTOs suggests their positive influence as they expand their operations beyond patenting and licensing to developing contract/sponsored research and providing technology consulting services, thus broadening their revenue base. TTOs are now involved in a broad range of IP activities. ***TTOs do far more than simply ensure the protection of patentable inventions.*** They are often involved in protecting and exploiting innovations in a number of technological fields. Still, even in the US few TLOs generate sufficient license income, even though ***US PREs far outperform their EU counterparts in terms of the average amount of license income earned per TTO or in terms of licence income as a proportion of research expenditure***[175].
- Across all countries ***the percentage of active patents ever licensed is somewhere between 20% and 40% and only about half of these licenses – 10% of the patent portfolio – earn income.*** Usually a small number of licenses account for a large part of a PRE's licensing income from IP, and a small number of PREs account for the majority of a country's total PRE licensing income.
- ***Patented inventions are not the most frequent object of licenses.*** Licenses for inventions with patent pending are especially significant because they are an indicator that TTOs license early-stage technologies to firms that subsequently invest in their further development. For some countries, exclusive licenses are rarely granted, while in others they are the quite common – Italian PRIs, the Netherlands, Japan and Belgium.
- Low incentives to patent and license are reinforced by the high costs of patenting and licensing, and the uncertainty over the potential revenue from licensing. ***Governments must encourage PRE patenting activity by lowering or subsidizing the cost of patent protection.*** Patent costs are lower in the US and Japan than those for filing a patent at the European Patent Office (EPO) with protection in several European countries. Nevertheless, the advent of a single, cost-efficient European patent could help widen the market for commercializing PRE inventions in Europe.

[175] On the latter, see for example the comparison between UK and US in Appendix 1 of Part II.

- ***PRIs seem to perform slightly better than Universities in technology transfer activities in some countries.*** This is particularly pronounced in the case of Germany.
- ***Non-IP related laws and regulations can be a barrier to technology transfer as well as fiscal rules that prevent PREs from receiving and retaining royalty income from licenses.***
- ***From the limited evidence available, revenue of PROs from contracts with industry has been rising in some countries though the rise is not large and is uneven – the rise is significant in countries that in the early 90s had weak traditions in Industry-Science Links (ISLs).*** Also, it is usually very concentrated in a few PROs that have established strong connections with industry.
- The overall picture that emerges is that in Europe – with the possible exception of UK and Germany – the ***patenting, licensing and commercialisation activities of Universities and other PRIs have not reached the size needed for having a significant impact on the R&D and innovation systems of the countries concerned.*** Nevertheless we can say that ***the European picture of significantly lagging behind in terms of university commercialisation and exploitation relative to USA is now changing, even if very slowly,*** as universities, governments across Europe and the Commission are exploring ways to more effectively 'capture' the benefits of university research and industrial collaboration.
- ***Creating professional patent and licensing agencies on a regional or sectoral basis, thus commercialising innovations for several universities, as practised in some countries, could strengthen commercialisation***.
- ***In several countries, such as Finland, Italy, Germany and Austria, mobility between universities and industry is still frequently hampered,*** especially for the academic partner, as university professors and other employees with the status of civil servants, are not encouraged to work temporarily in industry.
- Whereas mutual benefits can be expected to result from more intensive exchange between industry and PREs, certain long-term side effects may emerge. If PREs come to depend more on industrial demand and the income derived from it, they will risk abandoning their long-term, independent, and non-oriented fundamental research and becoming mere providers of practically-oriented knowledge, important for the immediate success of firms.
- While in the MSs of the EU, hundreds of policy measures and support mechanisms for science-industry cooperation have been implemented in recent decades, the diversity of these measures and schemes reflecting the diversity of each MS' infrastructure, cultural preferences, and political priorities, i***n general, cooperation between firms and universities or research institutes is still not sufficiently developed in the majority of member states.***

3. Public support to R&D measures of the Community's major trading partners

Lessons from the international fora

- Although the assurance of a level-playing field in the case of State aid is a generally accepted principle at the global level there are no enforcement mechanisms to control compliance or impose sanctions.

- The OECD takes a general stance that competition at country level should not create distortions; no specific guidelines or studies are undertaken by the organisation in the area of R&D.
- The WTO follows in principle the same philosophy with the EU, controlling State aid for trade distortion, but ***the major dissimilarity between them consists in their very different margins of enforcement***. Given its limited power the WTO plays a role of moderate transparency rather than assuring a level playing field among its members. However some of its procedures may offer interesting ideas for an improvement of the EU system.

General lessons from all competitors

- When comparing the EU R&D State aid regime with that of its main competitors the general conclusion is that they are not comparable in either content or their form.
- In terms of content the major difference consists in that *in all other cases the federal/central budget plays the dominant role* and contributes more than 85-95% of the total public funding. Thus any regulation with serious effects would have to be self-regulation, rather than a central authority controlling a lower level of governance.
- Further, in terms of content it is important to note that (with the exception of Japan, which has a very low share anyway) *direct government support to business R&D has declined both in absolute terms and as a share of business R&D in the OECD*. Indirect schemes, like tax incentives, the stimulation of entrepreneurship, venture capital and public private partnerships, with special emphasis in university-industry cooperation, are becoming more important.
- In terms of form only in the EU is State aid subject to formal trade distortion controls, in all major competitors there are no regulations in that respect.
- Because there is no such control the instruments are not comparable: the emphasis of scrutiny in competing countries is not in the internal distortion effect between States or regions but on the assurance of anti-trust respect; rules are suggested by actors (ministries or agencies), possibly debated in the Parliament and often evaluated but their application lies in the hands of peer reviewers. Potential internal rules to reviewers are not public knowledge.

Specific characteristics of interest

- Both in the US and in Japan (and even in smaller countries like Korea and Canada) mission oriented research is an important support instrument to the business sector. *When judged necessary all these countries seem to have the legal possibility to tailor schemes to industrial needs.*
- In the US despite the lack of regulation only in exceptional cases and in mission-oriented research are thresholds of 50% overtaken.
- Another interesting lesson from *the US is that, there are some very efficient and generous instruments, which are not direct but they assure important funding for particular categories of projects and companies*. Both bigger companies, in the form of mission-oriented research and smaller ones in the form of SBIR can benefit from them. These are support instruments over and above ATPs, the regular business R&D support instrument.

4. The various categories of research activities

On the standards categories

- The *standardised R&D and innovation definitions are useful for surveys and statistical coverage but unlikely to reflect and accurately describe the complexity of the R&D and its relation to innovation*. The neatly fitting linear approach and the extensive standardised definitions of the Frascati and Oslo Manuals are insufficient to cope with reality.
- The abandonment of the linear model in the theory demonstrates the difficulties in the real world and emphasises the constant interaction among the various research stages that lead to serious difficulties of distinguishing both the type of research undertaken and its uncertainty or quantifiable risk
- The best way to approach the justification for intervention is through the risk and uncertainty associated to a research project; however it is too difficult and costly to make such assessments ex ante, let alone define them for whole programmes.

On the specific aspects of support

- Because of the increasing complexity of research under competitive pressures there is a request by the business sector to ***incorporate activities closer to innovation like instruments for validation of research results,***
- Similarly, because of the changes circumstances and links among the various stages of research activities one should study the possibility ***to distinguish between blue sky and mission-oriented basic research.***
- Evaluations of additionality/ incentive effects are difficult, usually based on surveys and a proxy based on core versus non-core business activities risks to be misleading.
- The interaction with innovation is another relevant point. ***R&D related and science based innovations are more risk loaded than non-R&D innovation and should thus be treated differently, allowing for support*** as an ultimate stage of R&D, provided the connection between the two and a strong element of risk can be demonstrated.
- There is a need to distinguish between firms that are in a position to finance their growth and those which are not and still have a growth potential. In some cases *it is less the type of expenditure which should prescribe the need for a potential higher ceiling and more the type of project and/or the type of company requesting support*.

On the procedures

- Effectiveness does not only depend on the content but also on the way procedures are established. Unclear rules are subject to different interpretations and create distortions. *Clear and easy to apply rules are imperative.*
- The clarity of rules is important not only for the schemes that are implemented but also because they may trigger a *dissuasion effect.* While there are almost no negative decisions regarding notifications and MSs and regions all have now a variety of support schemes, it may be argued that there is limited experimentation with new schemes in Europe for sheer fear of too lengthy procedures.

5. The leverage effect of R&D State aid, in terms of its potential to stimulate additional private R&D investment

- Despite the heterogeneity of the empirical models referred to in the literature, examining the relationship between public R&D subsidies and private R&D

investment, which makes any comparison exercise hazardous, the balance seems to tilt towards the recognition of a complementary relation. Complementarity appears more prevalent, and substitution effects all but vanish, among the subgroup of studies that have investigated this relationship at the industry and national economy levels, indicating ***strong positive spillover effects of subsidies***.

- ❖ At the same time, many studies on the impact of fiscal incentives, both at the macroeconomic and the microeconomic level, indicate that a decline in the cost of performing R&D generates additional R&D investments implying that this type of financial measure stimulates the total amount of R&D undertaken. ***R&D State aid in the form of subsidies seems to be more effective than R&D aid granted through tax relief or equity.***
- ❖ ***PREs' investment in R&D appears to be complementary to R&D State aid.***
- ❖ The promotion of RJVs has been one of the major policy instruments used by the Commission for over two decades, in its attempt to raise EU R&D. Empirical studies indicate that the formation of RJVs is efficient, as it tends to be associated with higher levels of R&D spending of the participating firms and raises their research productivity. Further, ***government-sponsored co-operative R&D serves as a complement to private R&D and RJVs are more innovative when they are subsidised than when they are not.***
- ❖ In the case of ***guarantee measures*** there are very few studies and evaluations making it difficult to make predictions about their probable impact.
- ❖ Since there is not only one type of financial instrument aimed at fostering business R&D, ***there is a strong need for co-ordination between the various institutions involved in financing.*** What constitutes an "effective" mix of direct (by form of subsidies) and indirect measures (by form of fiscal incentives) depends, to a high degree, on the specific conditions in MSs, i.e. on framework conditions and on the state of the respective national innovation system, its institutions and their strategies. There is evidence that the effectiveness of one instrument depends on the use of other instruments in the system of public support to R&D. Unfortunately, despite the fact that it is essential, ***at least at present co-ordination of instruments seems to be insufficient in many countries.***

6. A Policymaker's Perspective on State aid: Main Conclusions from the Questionnaire Survey

- ❖ Even though there are many theoretical arguments for a reconfiguration of the categories used in the R&D State aid framework, there is little pressure amongst the policymaking community in the EU for a change in these categories or for a readjustment of the ceilings within them.
- ❖ Similarly, there is little enthusiasm for broadening the range of 'special circumstances' warranting higher ceilings, or for the modification of ceilings within existing categories denoting 'special circumstances'.
- ❖ In contrast, there is pressure for change at the boundary between R&D and innovation, with the boundary redrawn to allow some of the innovation-related activities closely linked to R&D to fall within the R&D State aid framework. There is, however, little accord concerning the ways in which the boundary could be redrawn or the activities which should be affected.

- There are also indications that changes will be needed to refine the State aid rules governing PROs given the changing nature of their interaction with the private sector. Some of the guidelines concerning the transfer of IPRs from public to private sector bodies are in particular need of clarification.
- At an operational level, the policymaking community in the EU is broadly satisfied with the classification scheme used to define eligible costs in the R&D State aid framework, though many recognise that there is always room for greater transparency, simplification and flexibility.
- There are also few complaints about the over zealous application of State aid rules, since few proposed initiatives have had either to be modified drastically or to be abandoned as a consequence of clashes with the current State aid regime. There is dissatisfaction, however, with the length of time it takes for initiatives to be rubber-stamped after they have been notified.
- Policymakers concur that the effectiveness of R&D State aid needs to be assessed in terms of both its leveraging effect on private sector R&D levels (with risk and additionality as important *ex ante* criteria) and its downstream impact on variables such as innovation and competitiveness (both directly and indirectly via spillover effects).
- Assessments of both are hindered by the wide variety of support instruments; by the lack of any common guidelines for the definition and assessment of leverage; by the sheer range of factors which theoretically have to be taken into account in impact assessments; and by the intractable nature of many of the problems relating to the assessment of causality and attribution.

References-Bibliography

1. Adams, James D., (1990), “Fundamental Stocks of Knowledge and Productivity Growth”, Journal of Political Economy 98, 673 – 702.
2. Adams, James D., (1999), “Endogenous R&D spillovers, invisible R&D, and industrial productivity”, presentation at the American Economics Association meetings, New York, January.
3. Adams, J.D., E.P. Chiang, and K. Starkey, (2001), “Industry-University Cooperative Research Centers”, Journal of Technology Transfer, Vol. 26, No. 1/2: 73–86.
4. Aerts K. and Czarnitzki D. (2004), “Using Innovation Survey Data to Evaluate R&D Policy: The Case of Belgium”,ZEW.
5. Aghion, P and Howitt, P (1992), “A model of growth through creative destruction”, Econometrica, March, 323-351.
6. Aghion, P., Harris, C., Vickers J. (1997), “Competition and Growth with Step-by-Step Innovation: an example”, European Economic Review, 41, pp. 771-782.
7. Aghion, P and Howitt, P (1998), “Endogenous Growth Theory”, Cambridge MA, MIT Press.
8. Aghion, P., Harris, C., Howitt, P. and Vickers J. (2001), “Competition, Imitation and Growth with Step-by-Step Innovation”, Review of Economic Studies, Vol. 68(3), pp. 467-92.
9. Aghion, P., Bloom, N., Blundell, R., R. Griffith and P. Howitt, (2001), “Empirical Estimates of the Relationship between Product Market Competition and Innovation”, mimeo, University College London.
10. Aghion, P., Bloom, N., Blundell, R., R. Griffith and P. Howitt, (2002), “Competition and Innovation: An Inverted U Relationship”, WP
11. Aldrich, H.E. and T. Sasaki (1995), “R&D Consortia in the United States and Japan”, Research Policy, 24, 301-316.
12. Allen, T.J., (1977), “Managing the Flow of Technology”, The MIT Press.
13. Almus M and Czarnitki D. (2002), “The effects of Public R&D Subsidies on Firms’ Innovation Activities: The Case of Eastern Germany”, ZEW
14. Amir, R. (2000), “Modelling Imperfectly Appropriable R&D Via Spillovers”, International Journal of Industrial Organization, Vol. 18(7), pp. 1013-1032.
15. Antonelli, Cristiano, (1989), “A failure-inducement model of research and development expenditure”, Journal of Economic Behavior and Organization 12, 159-180.
16. Arrow, Kenneth J., (1962), “Economic welfare and the allocation of resources to invention”, in Nelson, Richard (ed): The Rate and Direction of Inventive Activity. New Jersey, Princeton University Press.
17. Arrow, Kenneth J., (1962), “The economic implications of learning by doing”, Review of Economic Studies, 29(2), pp. 155-173.
18. Arrow, K. (1987), “Reflections on the essays”, in G. Feiwel (ed.), Arrow and the Ascent of Modern Economic Theory, Macmillan, New York
19. Arup Economics & Planning (2000), “Evaluation of Regional Selective Assistance 1991-1995”, Arup Economics & planning, London.
20. Asmussen, E., Berriot, C., (1993), “Le credit d-impot recherché, cout et effet iniciatif”, Ministere de l’ Economie et des finances, Paris.
21. Audretsch, D.B., W.J. Baumol and A.E. Burke, (2001), “Competition Policy in Dynamic Markets”, International Journal of Industrial Organization, Vol. 19(5), pp. 613-634.
22. AUTM Journal (Journal of the Association of University Technology Managers), (2002), “National Survey of Research Commercialisation Year 2000”, AUTM, Northbrook, Illinois.
23. AUTM, (2004),” AUTM Licensing Survey: FY 2003”, AUTM, Northbrook, Illinois.
24. Baily, M. and H. Gerbach (1995), “Efficiency in Manufacturing and the Need for Global Competition”, Brooking Papers on Economic Activity: Microeconomics, 307-347

25. Bartelsman, Eric J., (1990), "Federally Sponsored R&D and Productivity Growth", Federal Reserve Economics Discussion Paper No. 121, (Federal Reserve Board of Governors, Washington, D.C.).
26. Bayoumi, T., David T. Coe and E. Helpman (1998), "R&D spillovers and global growth", Journal of International Economics, vol. 47, no. 2 (April), pp. 399-428.
27. Beath, J., Katsoulacos, Y. and Ulph, D., (1995), "Game Theoretic Approaches" in P. Stoneman (ed.), Handbook of the Economics of Innovation and Technological Change, Oxford, Basil Blackwell.
28. Beath, J., Poyago-Theotoky, J and D. Ulph, (1998), "Organization Design and Information-Sharing in a Research Joint Venture with Spillovers", Bulletin of Economic Research, 50, 47-59.
29. Beath, John, Owen, Robert, Poyago – Theotoky, Joanna and Ulph, David, (2000), "Optimal Incentives for Income-Generation within Universities", mimeo, University College London.
30. Beath, John, Katsoulacos, Yannis and Ulph, David, (1999), "Notes on Fundamental Research and the Role of Markets", mimeo, University College London.
31. Beath, John, Katsoulacos, Yannis and Ulph, David, (2001), "University - Firm RJVs" mimeo, University College London.
32. Bekkers, R. and B. Sampat (2003), "Rapporteurs Summary Report", commissioned by the OECD for the Joint OECD-Netherlands Expert Workshop on the Strategic Use of IPRs by Public Research Organisations. Available at: www.oecd.org/pdf/M00037000/M0037899.pdf.
33. Bernstein, J.I., (1986), "The effect of direct and indirect tax incentives on Canadian industrial R&D expenditures", Canadian Public Policy, XII, 438-448.
34. Bernstein, J. I and Nadiri, M. I., (1988), "Interindustry R&D Spillovers, Rates of Return and Production in High-Tech Industries", American Economic Review, 78, (Papers and Proceedings), pp. 429-434.
35. Besley, T. abd P. Seabright, (1999), "The Effects and Policy Implications of State Aids to Industry: An Economic Analysis", Economic Policy, Vol. 28 pp. 14-53.
36. Bibbens, T. (1996), "Innovation, Commercialization, and SBIR: It's Déjà Vu All Over Again", The Small Business Advocate, Vol. 15, pp. 6-7.
37. Blank, David M., and George J. Stigler, (1957), "The Demand and Supply of Scientific Personnel (National Bureau of Economic Research, Inc., New York).
38. Bloom, N, Griffith, R, and Van Reenen, J., (1999), "Do R&D Tax Credits Work?" Evidence from an International Panel of Countries 1979-1994, Institute for Fiscal Studies Working Paper, W99/8.
39. Blundell, R., R. Griffith and J. Van Reenen, (1999), "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms", Review of Economic Studies, Vol. 66, pp. 529-554
40. Boone, J. (2000), "Competitive Pressure: the effects on investments in product and process innovation", "RAND Journal of Economics, Vol. 31(3), pp. 549-569.
41. Boone, J. (2001), "Intensity of Competition and the Incentive to Innovate", International Journal of Industrial Organization, Vol. 19(5), pp. 705-726.
42. Bound, J. C. Cummins, Z. Griliches, B.H. Hall and A.Jaffe (1984), "Who Does R&D and Who Patents?" In Z. Griliches: R&D, Patents and Productivity, The University of Chicago Press (Chicago).
43. Branstetter, L. G. and M. Sakakibara (2002), When Do Research Consortia Work Well and Why? Evidence from Japanese Panel Data, American Economic Review 92(1), 143-159
44. Brod, A. and R. Shivakumar, (1999), "Advantageous Semi-Collusion", The Journal of Industrial Economics, Vol. XLVII (2) pp 221-30.
45. Brofoss et al. (2004), "Evaluating the WBSO: study of the effectiveness of the WSBO", PriceWaterhouseCoopers
46. Buigues, P., A. Jacquemin and A.Sapir, (1995), "Complementarities and Conflicts in EC Microeconomic Policies", in P. Buiques, A. Jacquemin and A.Sapir, (Eds), European

Policies on Competition, Trade and Industry, Edward Elgar, Adelshot, UK-Brookfield, US
47. Bulder, B. (2004), “Effectief evalueren; zeven adviezen voor de strategie van evaluatieonderzoek”, in: BASIS, periodiek voor beleids-en consumentenonderzoek 2004, evaluatie-special, pp 30-32.
48. Busom, Isabel, (1999), “An Empirical Evaluation of the Effects of R&D Subsidies”, (Working Paper No. B99-05, Universitat Autonoma de Barcelona).
49. Caballero, Ricardo J. & Jaffe, Adam B., (1993), “How High are the Giants' Shoulders: An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth”, NBER Working Papers 4370, National Bureau of Economic Research, Inc.
50. Cabo, Pépin G., (1997), “The knowledge network, European subsidized research and development cooperation”, Chapter 5: The Knowledge Intensity of EUREKA Projects
51. Cacciato, Giuseppe, (1996), “Subsidies, Competition Laws and Politics: A Comperison of the EU and the USA”, University of Pittsburg, Centre for West European Studies, European Policy Paper Series.
52. Cameron, G. (1996), “Innovation and Economic Growth”, Discussion Paper No.277, Center for Economic Performance, London School of Economic and Political Science (February).
53. Capron, H. (1992), “Economic Quantitative Methods for the Evaluation of the Impact of R&D Programs”, Comission of the European Communities, Monitor/Spear, EUR 14864 EN.
54. Capron, H. and B. Van Pottelsberghe De La Potterie, (1997), “Public support to business R&D: A survey and some new quantitave evidence”, in "Policy evaluation in innovation and technology", OECD, pp.35-47
55. Capron, H. and Van Pottelsberghe De La Potterie, (1997), “Issues in measuring the relationship between government and private R&D, mimeo, Universite Libre de Bruxelles.
56. Carbaugh, R.J., Olienyk, J. (2004), “Boeing - Airbus Subsidy Dispute: A Sequel”, Global Economy Journal, Vol. 4, issue 2, article 6.
57. Carlsson B. and Frihd A.C., (2000), “Technology Tranfer in United States Universities”, paper presented at the “The Eighth International Joseph A. Schumpeter Society Conference-The Millennium Conference Change, Development and Transformation: Transdisciplinary Perspectives on the Innovation Process, Manchester/UK 28th June-1st July 2000”
58. Carmichael, Jeffrey, (1981), “The effects of mission-oriented public R&D spending on private industry”, Journal of Finance 36, 617-627.
59. Cesaroni, Fabrizio and Piccaluga, Andrea, (2003), “Technology Transfer from Italian Universities: Is an entrepreneurial model starting-up?”.
60. Charles, D. and Howells, J. (1992), “Technology Transfer in Europe: Public and Private Networks” Belhaven, London.
61. Clarysse B, Bilsen V, Steurs G, Larosse J, (2004), “Measuring additionality of R&D subsidies with surveys: Towards an evaluation methodology for IWT-Flanders, in “Making the Difference”. The Evaluation of “Behavioural Additionality” of R&D Subsidies, IWT-Observatory.
62. CNRS (2001), “Rapport d’activité du CNRS 2000”.
63. Cohen, W. and Levin, R. (1989), “Empirical Studies of Innovation and Market Structure” in R. Schmalensee and R. Willig Handbook of Industrial Organization (Amsterdam: North-Holland).
64. Cohen, W.M. and S.Klepper (1996), “A Reprise of Size and R&D”, Economic Journal 106, 925-951.
65. Cohen, W., R. Nelson, L. Walsh, (2000), “Protecting their intellectual assets: Appropriability conditions and why U.S manufacturing firms patent (or not). NBER working paper, No. 7552, Cambridge MA.

66. Collie, D. R., (1999), "Prohibiting State Aid in an Integrated Market: Cournot and Bertrand Oligopolies with Differentiated Products", Cardiff Business School Discussion Paper 99-101.
67. Collie, D. R., (2000), "State Aid in the European Union: The Prohibition of Subsidies in an Integrated Market", International Journal of Industrial Organization, Vol 18, pp. 867-884.
68. Collins, E., (1983), "An early assessment of three R&D tax incentives provided by the Economic Recovery Tax Act of 1981", Vol. PRAReport 83-7. National Science Foundation, Washington, DC.
69. Commission of the European Communities (CEC), (1993), International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank (1994), System of National Accounts.
70. Commission of the European Communities, Reports: State aid Scoreboards, 2001 – 2005.
71. Commission Communication, (2004), "A new framework for the assessment of State aid of lesser concern".
72. Community guidelines on State aid to maritime transport (OJ C 205 of 05.07.1997, page 5).
73. Conference Board of Canada (1998), "Making University-Industry Collaborative Research Work"
74. Cooper A.C (1971), "Spin-offs and Technical Entrepreneurship", IEEE Transactions on Engineering Management, EM-18(1).
75. Cox D, Gummett P and Barker K, (2001), "Government Laboratories – Transition and Transformation, Amsterdam: IOS Press.
76. Crépon, B., Duguet, E., Encaoua, D. and Mohnen, P., (1992), "Cooperative, Non-cooperative R&D and Optimal patent life", INSEE Discussion Paper 9208.
77. CREST Report (2004), "Open Method of Co-ordination (OMC)-3% Action Plan", Report of the CREST Expert Group on The Public Research Base and its Links with Industry.
78. Czarnitzki, D. and A. Fier (2001), "Do R&D Subsidies matter? Evidence for the German Service Sector", ZEW Discussion Paper 01-19, Mannheim.
79. Czarnitzki and Fier (2004), "Publicly Funded R&D Collaborations and Patent Outcome in Germany", ZEW
80. Dagenais, M., Mohnen, P., Thierrien, P., (1997), "Do Canadian Firms Respond to Fiscal Incentives to Research and Development?", Tilbung University mimeo.
81. Dasgupta, P. and J. Stiglitz (1980), "Industrial Structure and the Nature of Innovative Activity", The Economics Journal, 90, 266-293.
82. Dasgupta and David (1987), "Information Disclosure and the Economics of Science and Technology", in G. Feiwel (ed.), Arrow and the Ascent of Modern Economic Theory, Macmillan, New York, 519-42.
83. D'Aspremont, C. and A. Jacquemin (1998), "Cooperative and Non-cooperative R&D in a Duopoly with Spillovers", American Economic Review, 78: 1133-1137.
84. David, Paul A., (1998), "Common Agency Contracting and the Emergence of Open Science Institutions", American Economic Review, 88(2): 15-21.
85. David, Paul A., (1998), "The political economy of public science", in Helen Lawton Smith, ed., The Regulation of Science and Technology, (London: Macmillan Publishers).
86. David, Paul, Bronwyn Hall, and A. Toole (1999), "Is public R&D a complement or substitute for private R&D?", NBER working paper No.7373.
87. David, Paul, and Bronwyn Hall, (1999), "Heart of darkness, public-private interactions inside the R&D black box. (Nuffield College, Oxford: Economics Discussion Paper No. 1999-W-16, March).
88. David, P., A. and Hall Bronwyn H., (2000), "Heart of Darkness: modelling public-private funding interactions inside the R&D black box", Research Policy, 29, pp. 1165-1183.
89. Debackere, Koenraad and Veugelers, Reinhilde, (2002), "Improving Industry Science Links through University Technology Transfer Units, An Analysis and a Case".

90. DeBondt, R. and Changqi, Wu., (1997), "Research Joint Venture Cartels and Welfare" in Poyagou-Theotoky (Ed).
91. DG Research Report, "Towards a European Research Area – Science, Technology and Innovation: Key Figures 2003-4" EUR 20735,
92. Diamond, Arthur M., (1998), "Does federal funding crowd out private funding of science?", presentation at the American Economics Association meetings, Chicago, January.
93. Duguet, E. (2003), "Are R&D subsidies a substitute or a complement to privately funded R&D? Evidence from France using propensity score methods for non-experimental data", Reveue d'Economie Politique 114(2), 263-292.
94. Dunning, J.H. and P. Robson (eds.) (1988), "Multinationals and the European Community", Basil Blackwell, New York.
95. DTI (1998), Our Competitive Future: Building the Knowledge Driven Economy, Cmnd 4178, HMSO, London.
96. Eaton, J, Gutierrez, E, and Kortum, S, (1998), European Technology Policy, Economic Policy 27, 403-438.
97. EICTA (2000), "EICTA Position on the Revision of the EU rules on State Aid for R&D", Position Paper, Brussels.
98. Encaoua, D. and D. Ulph, (2000), "Catching-up or Leapfrogging? The Effects of Competition on Innovation and Growth", Eurequa W.P. 2000.97, Université de Paris I.
99. Encaoua, D. and Hollander, A., (2002), "Competition Policy and Innovation", Oxford Review of Economic Policy, Vol. 18(1), pp 63-79.
100. Enterpise Europe News Update, Innobarometer 2004, enterprice-europe-no-response@cec.eu.int
101. European Commisison (1995), Identifying the Structural Effects of Community Interventions, MEANS handbook No.2, Luxembourg
102. European Commission (1997), Evaluating EU Expenditure programmes: A Guide; Ex post and intermediate Evaluation
103. European Commission (1999), the Collection: Evaluating Socio-Economic Programmes, Luxembourg: Office for Official Publications of the European Communities
104. European Commission, (2000), "Eighth Survey on State Aid in the European Union", COM(2000)205 final, Brussels.
105. European Commission, DG Enterprise (2001), "Corporation Tax and Innovation", Innovation Paper No 19, Brussels
106. European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Guarantee Mechanisms", EC
107. European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Fiscal Measures", EC
108. European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Direct measures", EC
109. European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development-Risk Capital Measures", EC
110. European Commission, (2003), "Raising EU R&D Intensity-Improving the Effectiveness of the Mix of Public Support Mechanisms for Private Sector Research and Development", EC
111. European Commission, DG Enterprise, "Corporation Tax and Innovation", Innovation Papers No. 19, Brussels.
112. European Commission, DG Research "Towards a European Research Area – Science, Technology and Innovation: Key Figures 2003-4" EUR 20735 EN.
113. European Parliament, Resolution of 11.4.2002, Report A5-0020/2002, point 17.

114. European Trend of Innovation, "Innovation policy in Europe (2001)", A publication from the Innovation/SMES Programme part of the Fifth Framework Programme.
115. Eurostat, (2001), "Statistics on Science and Technology in Europe: Data 1985–99", Luxembourg, European Communities.
116. Ergas, H. (1987), "Does technology policy matter?", in B.Guile and H.Brooks (eds). Technology and global industry. Washington D.C.: National Academy Press.
117. Federal Ministry of Education and Research, (2002), "Germany's Technological Performance 2001", pp. 155-157.
118. Fershtman, C. and N. Gandal, (1994), "Disadvantageous semicollusion", International Journal of Industrial Organization, Vol. 12, pp. 141-54.
119. Fingleton, J., Ruane, F. and Ryan V., (1998), "Market Definition and State Aid Control", European Economy, No 3.
120. Florida R., (1999), "The role of the University: Leveraging Talent, Not Technology", Issues on Science and Technology, Vol. XV. N.4, 67-73.
121. Folster, S. and G. Trofimov (1996), "Do subsidies to R&D actually stimulate R&D investment?", mimeo, The Industrial Institute of Economic and Social Research.
122. Fransman, M. (1990), "The Market and Beyond: Co-operation and Competition in Information Technology Development in the Japanese System", Cambridge University Press, Cambridge.
123. Freeman, C., Soete L. (1997), "The Economics of Industrial Innovation", The MIT Press, Cambridge Massachusetts.
124. Friederiszick H.W, Roller L-H and Neven D.J (2004), "Evaluation of the effectiveness of state aid as a policy instrument" Final Report, DG ECFIN
125. Frontier Economics, (2004), "Annexe C-The effects of Public Subsidies on Competition", Office of Fair Trading.
126. Fuglie, K. et al. (1996), "Agriculture Research and Development: Public and Private Investments Under Alternative Markets and Institutions", Agricultural Economics Report No 735, Natural Resources and Environment Division, Economic Research Service, United States Department of Agriculture.
127. Galdon-Sanchez, J. and J. Schmitz (2002), "Competitive Pressure and Labor Productivity: World Iron-Ore Markets in the 1980's", American Economic Review, 92, 4, 1222-1235.
128. Garcia C.E & L.S. Menendez (2002), "From research to patents within Spanish PROs", CSIC Working paper 02-26.
129. Gering, T., Schmoch, U. and Werner, O., (2002), "Case Study on Intellectual Asset Management in German PROs and IP in the German Biotechnology Sector", Unpublished draft to the OECD Focus Group on Innovation and IPRs, OECD, Paris.
130. Geroski, P., (1990), "Innovation, Technological Opportunity, and Market Structure", Oxford Economic Papers, 42,3, 586-602.
131. Geroski, P., (1994), "Market Structure, Corporate Performance and Innovative Activity", Oxford: Oxford University Press.
132. Geroski, P., (1995), "Markets for Technology: Knowledge, Innovation and Appropriability", in P. Stoneman (ed.), Handbook of the Economics of Innovation and Technological Change, Oxford, Basil Blackwell.
133. Guena A. and Nesta A. (2003), "University Patenting and its Effects on Academic Research", SPRU Electronic Working Paper Series, 99, SPRU-University of Sussex, Brighton (UK).
134. Gonzalez, X., J. Jaumandreu and C. Pazo (2004), "Barriers to innovation and subsidy effectiveness", mimeo, Madrid.
135. Goolsbee, Austan, (1998), "Does government R&D policy mainly benefit scientists and engineers?" American Economic Review 88, 298-302.
136. Gracey, A.D. (2001), "Guarantee Mechanisms for Financing Innovative Technology-Survey and analysis", European Commission: Luxembourg
137. Gravenitz, G. and Ulph, D., (2000a), "A Comparative Welfare Analysis of Research Joint Ventures and Licensing under Strongly Additive R&D", mimeo, University College London.

138. Gravenitz, G. and Ulph, D., (2000b), “Technology Policy with Complementary Research Paths: The complementary Roles of RJVs and R&D Subsidies” Programme CNRS: Les Enjeux Economiques De l’Innovation, Cahier No. 00020.
139. Griffith, R, Sandler, D, and Van Reenen, J, (1995), “Tax incentives for R&D”, Fiscal Studies, 16, 21-44.
140. Griliches, Z. (1979), “Issues in Assessing the Contribution of Research and Development to Productivity Growth”, Bell Journal of Economics, 10(1), 92-116.
141. Griliches, Z. (1980), “Returns to research and development in the private sector”, in: Kendrick, John W., and Beatrice Vaccara, eds., New Development in Productivity Measurement and Analysis (Chicago: University of Chicago Press).
142. Griliches, Z., (1992), “The Search for R&D Spillovers”, Scandinavian Journal of Economics 94 pp. 29-47.
143. Griliches, Z., (1994), “Productivity, R&D, and the Data Constraint”, The American Economic Review, vol. 84, no. 1, pp. 1-23.
144. Griliches, Z., (1995), “R&D and Productivity: Economic Results and Measurement Issues”, in Paul Stoneman, ed., Handbook of Economics of Innovation and Technological Change, Oxford: Basil Blackwell.
145. Guellec, D. and E. Ioannidis, (1998), “Causes of fluctuations in R&D expenditures – A quantitative analysis”, OECD Economic Studies, 29, 1998/II.
146. Guellec, D. and Van Pottelsberghe (1999), “Does Government Support Stimulate Private R&D?” OECD Economic Studies, OECD, Paris.
147. Guellec, D. and Van Pottelsberghe (2000), “The Impact of Public R&D Expenditure on Business R&D”, STI Working Papers 2000/4, OECD, Paris.
148. Guellec, Dominique and Bruno van Pottelsberghe de la Potterie (2001), 'R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries', OECD Economic Studies 33: 103-126.
149. Gummet, P. et al. (2000), The changing central government of science and technology, in: Rhodes, R.A.W. (ed.): *Transforming British Government. Vol.2: Changing roles and relationships*. MacMillan, Houndsmills.
150. Hagedoorn, J. (1995), “A note on International Market Leaders and Networks of Strategic Technology Partnering”, Strategic Management Journal, 16, pp. 241-250
151. Hagedoorn, J. and R. Narula (1996), Choosing organisational modes of strategic technology partnering: international and sectoral differences, Journal of International Business Studies 27, 265-284
152. Hagstrom, W.O. (1965), “The Scientific Community”. New York: Basic Books
153. Hahm, S. D., Plein, L.C. (1995), “Institutions and Technological Development in Korea: The Role of the Presidency”, Comparative Politics, Vol. 28, No. 1, October 1995, pp. 55-76.
154. Hall, Brownyn H., (1993), “R&D tax policy during the eighties: success or failure? Tax Policy and the Economy 7, 1-36.
155. Hall, Brownyn H., (1996), “The private and social returns to research and development”, in: B. Smith and C. Barfield, eds., Technology, R&D, and the Economy (AEI-Brookings Institution, Washington, DC).
156. Hall, Brownyn H., and John Van Reenen, (1999/2000), “How effective are fiscal incentives for R&D? A review of the evidence”, Research Policy 29: 449-469.
157. Hamberg, Daniel, (1966), “R&D: Essays on the economics of research and development” (New York: Random House).
158. Hamilton, W.F., Mitchell, G.R. (1988), “Managing R&D as a Strategic Option” in Research, Technology Management, Vol. 31, No. 3.
159. Hamilton, W.F., Mitchell, G.R. (1990), “What is your R&D worth?” in The McKinsey Quarterly, No. 3.
160. Hartley, K., (2000), “Defence Economics and the Industrial Base, Centre for Defence Economics”, University of York.
161. Hausman, J. (2001), “Microeconomics”, Journal of Econometrics 100, 33-35.

162. Hebner, R. E. (1998), "Industrial Innovation in the United States: The Complementary Role of the Federal Government", presented at the APEC R&D Leaders Forum, Taipei, Taiwan.
163. Henderson, R., A. Jaffe, M. Trajtenberg, (1998), "Universities as a source of commercial technology: A detailed analysis of university patenting, 1965-1988", Rev. Economics and Statistics 65 119-127.
164. Hervik, A., Waagø, S., (1997), "Evaluering av Brukerstyrt forskning", Trondheim / Oslo.
165. Higgins, Richard S., and Albert N. Link, (1981), "Federal support of technological growth in industry: some evidence of crowding out, IEEE Transactions on Engineering Management EM-28, November, 86-88.
166. Hill, Christopher, (1995), "Private funds are unlikely to replace cuts in public funds for R&D in the U.S." (Working Paper: The institute of Public Policy, George Mason University).
167. Hinloopen, J. (1997a), "Subsidizing Cooperative and Non cooperative R&D in Duopoly with Spillovers", Journal of Economics, 66, 151-175.
168. Hinloopen, J. (1997b), "Subsidizing Cooperative and Non cooperative R&D: an equivalence result?" Economics of Innovation and New Technology (forthcoming).
169. Hinloopen, J. (2000), "Subsidizing R&D Cooperatives" (mimeo).
170. Holemans, Benni, and Leo Sleuwaegen, (1988), "Innovation expenditures and the role of government in Belgium", Research Policy 17, 375-379.
171. Howe, J. D., and D. G. McFetridge, (1976), "The determinants of R&D expenditures", Canadian Journal of Econimics 9, 57-71.
172. Hull,D.L. (1988), "Science as a Process". Chicago: University of Chicago Press.
173. Husso, K., S. Karjalainen & T. Parkkari (eds.) (2000), "The state and quality of scientific research in Finland. A review of scientific research and its environment in the late 1990"s, Academy of Finland.
174. Hzkovitz, Fabienne, Roderick Meiklejohn and Jan Host Schmidt, (1999), "The Control of State Aids: A Proposal for a Co-ordinated Approach", for the Danish Competition Authority.
175. Industrial Research and Development Advisory Committee of the European Union (1998), "Draft IRDAC Opinion State aid for R&D", Brussels.
176. Innocult (Internationalisation of Research: Institutional Innovation, Culture and Agency in the Framework of Competition and Co-operation project consortia), (1999), "Analysing National Research Systems, Culture and RTD Co-operation".
177. International Labour Organization, (1990), "International Standard Classification of Occupations: ISCO-88", Geneva.
178. Irwin, Douglas A. and Peter J. Klenow (1995), "High-tech R&D subsidies: Estimating the effects of Sematech", in Journal of International Economics 40, 323-344.
179. Jaffe, A. (1986), "Technological Opportunity and Spillovers of R&D: Evidence form Firms", Patents, Profits, and Market Value, American Economic Review, 75(6), 984-1002.
180. Jaffe, A. (1989), "Real Effects of Academic Research", American Economic Review 79, 957-970.
181. Jaffe, A., (2000), "The US Patent System in Transition: Policy Innovation and the Innovation Process", Research Policy, 29, p. 534-557.
182. Jankowski, J. (1998), "R&D: The Foundation for Innovation. Changes in U.S. Industry." In Trends in Industrial Innovation: Industry Perspectives and Policy Implications, pp. 201–211. Research Triangle Park, NC: Sigma Xi, The Scientific Research Society, Inc.
183. Jansen Schoonhoven, P. and M. Vos (1998), "Ex Ante en Ex Post Evaluatie-Onderzoek: verschillen, overeenkomsten en afstemmingsmogelijkheden verkend" in: J.C. Hellendoorn et al. (eds.), Gewikt en Gewogen; Vijventwintig jaar Beleidsanalyse, Sdu Uitgevers, Den Haag, pp. 347-366
184. Jones, C., and J. Williams (1998), "Measuring the social returns to R&D", Quarterly Journal of Economics, vol CXIII, no 4 (November), pp. 1119-1135.

185. Kamien, M., Muller, E. and Zang, I., (1992), "Research Joint Ventures and R&D Cartel", American Economic Review, 82, pp. 1293-1306.
186. Katsoulacos, Y., (1993), "EC R&D Support: Effects on the Cooperative Behaviour of Firms", European Community Office Publications, Luxembourg.
187. Katsoulacos, Y. and Ulph, D. (1998a), "Endogenous Spillovers and the Performance of Research Joint Ventures", Journal of Industrial Economics, 46, 333-357.
188. Katsoulacos, Y. and Ulph D., (1998b), "Innovation Spillovers and Technology Policy" Annales d'Economies et Statistiques, 49/50, 589-607.
189. Katsoulacos, Y. and Ulph D. (1999), "Endogenous Information Sharing and the Welfare Evaluation of Research Joint Ventures" (mimeo, University College London).
190. Katsoulacos, Y. and Ulph D. (2002), "The Economics of Research Joint Ventures", in Bitros G. and Katsoulacos Y. (Eds) "Essays in Economic Theory, Growth and Labour Markets – A Festschrift in Honor of E. Drandakis", Edward Elgar, Cheltenham, UK.
191. Katz, M., (1986), "An Analysis of Cooperative Research and Development", RAND Journal of Economics, 17 (Winter), pp. 527-543.
192. Katz, M. and Ordover, J., (1990), "R&D Cooperation and Competition", Brookings Papers, Microeconomics, pp. 137-203.
193. Kauko, K. (1996), "Effectiveness of R&D Subsidies – A Sceptical Note on the Empirical Literature", Research Policy, 25, pp. 321-323.
194. Kesteloot, K. and De Bondt, R., (1993), "Demand-Creating R&D in a Symmetric Oligopoly", Economics of Innovation and New Technology, 1993, Vol. 2, pp. 171-183.
195. Kesteloot, K. and Veugelers, R., (1997), "R&D Cooperation between Asymmetric Partners", in J. Poyago-Theotoky (ed.), Competition, Cooperation, Research and Development, Macmillan, Basingstoke.
196. Kitagawa, Fumi, (2004), "Innovation Systems, University-Business Networks and Regionalization of the Knowledge Economy in Japan", Regionalization of Innovation Policy - Option and Experiences - June 2004 Berlin.
197. Kleiknecht, A. and J.O.N. Reijnen (1992), "Why do firms Co-operate on R&D? An Empirical Study", Research Policy, 21, pp. 347-360.
198. Kleinfeld, G., Kave, D. (1998), "Red Light, Green Light? The 1994 Agreement on Subsidies and Countervailing Measures, Research and Development Assistance, and U.S. Policy", Journal of World Trade.
199. Klette, Tor Jakob, and Jarle Moen, (1998), "R&D Investment responses to R&D subsidies: a theoretical analysis and econometric evidence" (presentation to the NBER Summer Institute, July).
200. Klette, Tor Jakob, Jarle Moen, and Zvi Griliches, (1999/2000), "Do Subsidies to Commercial R&D Reduce Market Failures?", Microeconomic Evaluation Studies. Research Policy: this volume.
201. Kneller, R., (2001), "Technology Transfer: A Review for Biomedical Researchers", Clinical Cancer Research, Vol.7, pp. 761-774.
202. Knoll N (2003), "Business R&D and the Role of Public Policies for Innovation Support: A Qualitative Approach", WIFO.
203. Kodama, F. (1991), "Analysing Japanese High Technologies: The Techno-Paradigm Shift", Pinter
204. Krugman, P. (1995), "Increasing Returns, Imperfect Competition and the Positive Theory of International Trade", in: G.M. Grossman, K. Rogoff (eds): Handbook of International Economics, Vol. III, Amsterdam et al.: Elsevier, 1243-1277.
205. Lach, Saul (2000), "Do R&D Subsidies Stimulate or Displace Private R&D? Evidence from Israel", NBER Working Paper Series, WP 7943.
206. Lach, S. and R.M. Sauer (2001), "R&D, Subsidies and productivity", Working Paper, Hebrew University of Jerusalem, Department of Economics
207. Lechner, M. (1998), "Training the East German Labour Force-Microeconometric Evaluation of Continuous Training after Unification", Heidelberg.

208. Lenihan, H., M. Hart and S. Roper (2003), "Evaluation the net additionality of industrial development assistance in Ireland", Paper presented at the European Regional Science Association Conference in Jyväskylä, Finland
209. Lerner, J., (1999), "The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program", Journal of Business 72(3), 285-318.
210. Levin, Richard C., and Peter Reiss, (1984), "Tests of a Schumpeterian model of R&D and market structure", in Zvi Griliches , ed., R&D, Patents, and Productivity (Chicago: University of Chicago Press).
211. Levin, R., W. Cohen, D. Mowery, (1985), "R&D appropriability, opportunity and market structure: New evidence on some Schumpeterian hypotheses", Amer. Econom. Rev. 75 20-24.
212. Levin, R., A. Klevorick, R. Nelson, S. Winter, (1987), "Appropriating the returns from industrial R&D", Brookings Papers Econom. Activity 3 783-831.
213. Levin and Stephan (1991), "Research Productivity Over the Life Cycle: Evidence for American Scientists", American Economic Review, Vol. 81, No. 1, 114-32.
214. Levin-Rozalis, M. (2000), "Abduction: A logical criterion for programme and project evaluation" in: Evaluation, Vol. 6(4), pp. 415-432
215. Levy, David M., and Nestor E. Terleckyj, (1983), "Effects of government R&D on private R&D investment and productivity: a macroeconomic analysis", Ball Journal of Economics 14, 551-561.
216. Levy, David M., (1990), "Estimating the impact of government R&D", Economic Letters, 32, 169-173.
217. Leyden, Dennis P., and Albert N. Link, (1991), "Why are government and private R&D complements?", Applied Economics 23, 1673-1681.
218. Licht, G. (2003), "The role of additionality in evaluation of public R&D programmes", presentation for the 11th annual TAFTIE Seminar, held in Vienna on 24/25 November Lichtenberg, Frank R., (1984), "The relationship between federal contract R&D and company R&D", American Economic Review Papers and Proceedings 74, 73-78.
219. Lichtenberg, Frank R., (1987), "The effect of government funding on private industrial research and development: a re-assessment", The Journal of Industrial Economics 36, 97-104.
220. Lichtenberg, Frank R., (1988), "The private R&D investment response to federal design and technical competitions", American Economic Review 78, 550-559.
221. Lichtenberg, Frank R., and Donald Siegel, (1991), "The impact of R&D investment on productivity – new evidence using linked R&D-LRD data", Economic Inquiry 29, 203-228.
222. Link, Albert N., (1982), "An analysis of the composition of R&D spending" Southern Journal of Economics 49, 342-349.
223. Link, A.N. and L.L. Bauer (1987), "An Economic Analysis of Co-operative Research", Technovation, 6, pp. 783-820.
224. Link, Albert N. and John T. Scott, (1998), "Public Accountability: Evaluating Technology-Based Institutions", Norwell, MA: Kluwer Academic Publishers.
225. Link, A., (2001), "Federal Register Filings: The 2000 Update of the CORE Database". Report submitted to the National Science Foundation, Arlington, VA.
226. Link, A. N., D. Paton and D. S. Siegel (2002), "An analysis of policy initiatives to promote strategic research partnerships", Research Policy 31, 1459-1466
227. Link, A., Scott, J., (2004) Evaluation of ATP's Intramural Research Awards Program", prepared for Economic Assessment Office, Advanced Technology Program, National Institute of Standards and Technology.
228. Lint, L.J.O. (1992), "Real options analysis in advanced manufacturing technologies" in International Journal Computer Integrated Manufacturing, Vol. 5, No. 3, pp. 145-152.
229. Lint, L.J.O. (1992), "Options in advanced energy-related production processes" in International Journal of Production Economics, 27, pp. 257-264.
230. Lint, O. (2000), "Retrospective Insights from Real Options in R&D", Eindhoven Centre for Innovation Studies, The Netherlands, Working Paper 00.09.

231. Luehrman, T.A. (1998), "Investment Opportunities as Real Options: Getting Started on the Numbers" in Harvard Business Review.
232. Luehrman, T.A. (1998), "Strategy as a Portfolio of Real Options" in Harvard Business Review.
233. Mamuneas, T.P. and I.M. Nadiri (1996), "Public R&D Policies and Cost Behavior of the US Manufacturing Industries", Journal of Public Economics 63, 57-81.
234. Mansfield, E. and L. Switzer, (1984), "Effects if federal support on company-financed R&D: the case of energy", Management Science 30.
235. Mansfield, E., (1986), "The R&D tax credit and other technology policy issues", AEA Papers and Proceedings 76, 190-194.
236. Mark, M., G. Henry, and G. Julnes, (2000), "Evaluation: An Integrated Framework for Understanding, Guiding, and Improving Policies and Programs", San Francisco: Jossey-Bass.
237. Martin, S. (1994), "Private and Social Incentives to Form R&D Joint Ventures", Review of industrial Organisation, 9, 157-171.
238. Martin, S. (1995), "R&D Joint Ventures and Tacit Product Market Collusion", European Journal of Political Economy, 11, 733-741.
239. Martin, S. and P. Valbonesi (1999), "State Aid in Context", mimeo
240. Martin, Stephen and Scott, John T. (2000), "The nature of innovation market failures and the design of public support for private innovation", in Research Policy 29, 437-447.
241. Matkin, G.W., (1990), "Technology Transfer and the University", New York: MacMillan Publishing Company.
242. Meeusen, W., and W. Janssens (2000), 'Additionaliteit'– versus 'substitutie'-effecten van overheidssteun aan O&O in bedrijven in Vlaanderen: een econometrische analyse aangevuld met de resultaten van een kwalitatieve bevraging, IWT-Observatorium, Brussels
243. Mollgaard, P., (2004), "Competitive Effects of State Aid in Oligopoly", Centre of Industrial Economics.
244. Mosselman, M., Prince, Y. and R. Kemp, (2004), "Review of Methodologies to measure the effectiveness of state aid to SMEs", European Commission.
245. Motta, M., (1992a), "Cooperative R&D and Vertical Product Differentiation", International Journal of Industrial Organisation, 10, pp. 643-661.
246. Mowery, David C., (1998), "The Changing Structure of the U.S. National Innovation System: Implications for International Conflict and Cooperation in R&D Policy," Research Policy, vol. 27, pp. 639-654.
247. Mowery, D., and Sampat, B. (2001), "University Patents and Patent Policy Debates in the USA, 1925-1980", Oxford University Press, London and New York.
248. Mukherjee, A. (2004), "Collusion with Asymmetric R&D", Mimeo, University of Nottingham
249. Mundheim, R.H. and P.D. Ehrenhaft, (1984), "What is a 'Subsidy?' A Discussion Paper", in Don Wallace Jr. et al eds., Interface Three: Legal Treatment of Domestic Subsidies, The International Law Institute, Washington D.C, 1984.
250. Murphy, W.J. (1991), "R&D Cooperation among marketplace Competitors", Quorum Books, Westpoint, Connecticut.
251. Nadiri, M.I. (1993), "Innovations and technological spillovers", National Bureau of Economic Research Working Paper 4423 (August).
252. Nakagawa, T. (2003), 'The Creation of Intellectual Clusters in Japan' Director, Office for the Promotion of Regional R&D Activities, Science and Technology Policy Bureau, MEXT.
253. Narin, F., K. S. Hamilton, D. Olivastro (1997), "The Increasing Linkage between U.S. Technology and Public Science", Research Policy 26, 317-320.
254. National Research Council, (1999), "Funding a Revolution: Government Support for Computing Research, Report of the NRC Computer Science and Telecommunications

Board Committee on Innovations in Computing: Lessons from History", Washington DC: National Academy Press.
255. National Science Board, National Science Foundation, Division of Science Resources Statistics, (2004), "R&D Investments by Multinational Corporations", Science and Engineering Indicators 2004, Arlington, VA (NSB 04-01).
256. National Institute of Standards and Technology (NIST), (2004), "Measuring ATP impact: 2004 Report on Economic Progress", NIST.
257. Navaretti, B., D. Dasgupta, G. Maler and D. Siniscalco (1998), "Creation and Transfer of Knowledge: Institutions and Economic Incentives" Springer Verlag, Heidelberg.
258. Neary, J.P. (1994), "Cost Asymmetries in International Subsidy Games: Should Governments Help Winners or Losers?", Journal of International Economics, 37, 197-218.
259. Nelsen, L. (1998), "The Rise of the Intellectual Property Protection in the American University", Science, Vol.270, No.5356, pp. 1460-1461.
260. Nelson, R.R., (2002), "The Contribution of American Research Universities to Technological Progress in Industry", paper presented to the conference Science as an Institution. The Institutions of Science, Siena (Italy).
261. Nichols, N.A. (1994), "Scientific Management at Merck: An Interview with CFO Judy Lewent" in Harvard Business Review.
262. Nickell, S. J., (1996), "Competition and Corporate Performance", Journal of Political Economy, Vol. 104, pp. 724-746.
263. NSF (2004), "Science and Engineering Indicators U.S. and International Research and Development: Funds and Technology Linkages", NSF
264. OECD (1993), Frascati Manual, Paris.
265. OECD (1995), "Fiscal Measures to Promote R&D and Innovation"
266. OECD, (1996), "Public Support to Industry: Report by the Industry Committee to the Council at Ministerial Level", OECD/GD(96)82, 1996
267. OECD, (1997), "National Innovation Systems", Paris.
268. OECD, (1998 b), "University Research in Transition", Paris OECD.
269. OECD (1998), "Trends and Patterns of Public Support to Industry in the OECD Area", STI Review, Special Issue on Public Support to Industry, No 21, p. 13.
270. OECD (1998), "International Control and Discipline of Subsidies: the EU and WTO Surveillance Exercises", STI Review, Special Issue on Public Support to Industry, No 21, p. 25.
271. OECD (1999), Improving evaluation practices, Paris
272. OECD, (1999), "Research and Development in Industry: Expenditure and Researchers, Scientists and Engineers 1976–97", Paris.
273. OECD, (1999a), "Competition Policy and Procurement Markets", OECD Best Practice Roundtable No. 20, DAFFE/CLP(99)3FINAL,
274. OECD, (1999b), "Promoting Competition in Postal Services", OECD Best Practice Roundtable No. 24, DAFFE/CLP(99)
275. OECD, (2000a), "Harmful Forms of Policy-Based Competition to Attract Investments", DAFFE/IME(2000) 23,
276. OECD, (2001), "Benchmarking Industry-Science Relationships, Science, Technology and Industry".
277. OECD, (2001), "Competition Policy in Subsidies and State Aid", DAFFE/CLP (2001)24.
278. OECD, (2002), "Interim Results of the TIP Project on the Strategic Use of IPR at PROs", Internal Working Document.
279. OECD, (2002), "Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development", Paris.
280. OECD (2002), "Tax Incentives for Research and Development: Trends and Issues", STI.
281. OECD (2003), "Main Science and Technology Indicators".
282. OECD (2003), "Turning Science into Business: Patenting and Licensing at PROs".

283. OECD, (2004), "Main Science and Technology Indicators (MSTI)", 2004/2 edition.
284. OECD (2004), "OECD Science, Technology and Industry Outlook 2004", Paris.
285. OECD (2004), Science and Technology Statistical Compendium.
286. OECD (2005), Factbook See also: http://lysander. sourceoecd. org/vl =1704500/cl =67/nw=1/rpsv/factbook/06-01-01.htm
287. Ouchi, W.G. and M.K Bolton, (1998), "The Logic of Joint Research and Development", California Management Review, 30, pp. 9-33.
288. Parche, A. (1993), "'Messy' Research Methodological Predispositions, and Theory Development in International Joint venture", Academy of Management Review, 18, pp. 227-268.
289. Pavitt, K., (1998), "The social shaping of the national science base", Research Policy, 27, 8, 793-806.
290. Pawson, R. and N. Tilley (1997), "Realistic evaluation", Sage, London
291. Pisano, G., P. Mang, (1993), "Collaborative product development and the market for know how: Strategies and structures in the biotechnology industry", Res. Tech. innovation, Management Policy 5 109-136.
292. Polt W. et al. (2001), "Benchmarking industry-science relations – the role of framework conditions". Project commissioned by the European Commission, DG-Enterprise and the Austrian Federal Ministry for Economic Affairs and Labour (BMWA). Brussels, European Commission.
293. Porter, M.E. (1990), "The Competitive Advantage of Nations", London: Macmillan Press, 1990.
294. Posner, R. (2001), "Antitrust in the New Economy", University of Chicago, Olin Working Paper No 106.
295. Patterson, F., (2004), "Regaining Ground. Business Development and the SBIR Program in Texas", Texas Business Review.
296. Poyago-Theotoky, J., (1995), "Equilibrium and Optimal Size of a Research Joint Venture in an Oligopoly with Spillovers", Journal of Industrial Economics, 43, pp. 209-226.
297. Poyagou – Theotoky J.A (Editor) (1997), "Competition, Cooperation, Research and Development: The Economics of Research Joint Ventures" MacMillan Press Ltd, London.
298. PREST (2002), "A Comparative Analysis of Public, Semi-Public and Recently Privatised, Research Centres", CBSTII contract ERBHPV2-CT-200-01, Final Project Report Part 1: Summary Report Prepared on behalf of the project consortium.
299. Robson, Martin, (1993), "Federal funding and the level of private expenditure on basic research", Southern Economic Journal, 60,63-71.
300. Rogers, E. M. and Larsen, J., (1984), "Silicon Valley Fever", Basic Books, New York.
301. Romanainen (1999), "The Cluster Approach in Finnish Technology Policy", in OECD (ed.), Boosting Innovation: The Cluster Approach, Paris: Organisation for Economic Co-Operation and Development.
302. Romer, Paul M., (1990), "Are Nonconvexities Important for Understanding Growth?", American Economic Review 80: 97-103.
303. Rosenkranz, S., (1996), "Cooperation for Product Innovation", WZB, Editions Sigma, Berlin.
304. Rossi, P.H., H.E. Freeman and M.W. Lipsey (1999), "Evaluation; A systematic approach", Sage Publications, Thousand Oaks
305. Roy, A.D. (1951), "Some Thoughts on the Distribution of Earnings", Oxford Economic Papers 3, 135-146.
306. Rubin, D.B. (1974), "Estimating Causal Effects of Treatments in Randomized and Non-Randomized Studies", Journal of Educational Psychology 66, 688-701.
307. Rubinfeld, D. (1998), "Competition, Innovation and Antitrust Enforcement in Dynamic network Industries", Spring Symposium of Software Publishers Association, San Jose, California

308. Ruegg, R. and I. Feller, (2003), "A Tooklit for Evaluating Public R&D Investment-Models, Methods and Findings from ATP's First Decade", National Institute of Standards and Technology Gaithersburg.
309. Sakakibara, (1997), "Evaluation of Government-Sponsored R&D Consortia in Japan", in OECD (ed.), Policy Evaluation in Innovation and Technology-Towards Best Practices, Paris.
310. Sakakibara, M. (2001), The Diversity of R&D Consortia and Firm Behaviour: Evidence from Japanese Data, The Journal of Industrial Economics 49(2), 181-196
311. Salter A., D'Este P., Pavitt K., Scott A., Martin B., Guena A., Nightingale P. and Patel P., (2000), "Talent Not Technology: The Impact of Publicly Funded Research on Innovation in the UK, SPRU-Science and Technology Policy Research, University of Sussex, Brighton (UK).
312. Sanchez, A. M. and Tejedor, A-C. P. (1995) "University-industry relationships in peripheral regions: the case of Aragon in Spain" Technovation 15, 613-25.
313. Sauvé, P., (2002), "Completing the GATS Framework: Addressing Uruguay Round Leftovers", Aussenwirtschaft, 57. Jahrgang, Heft III, Zurich, Ruegger, S. 301-341.
314. Sawyer, A. J. (2004), "Potential Implications of Providing Tax Incentives for Research and Development in New Zealand", Report for the Royal Society of New Zealand.
315. Saxenian, A. (1985), 'Silicon Valley and Route 128: regional prototypes or historical exceptions' in Castells, M. (Ed.) High Technology, Space and Society Sage, Beverly Hills, CA.
316. Saxenian, A. (1994), "Regional Advantage", Harvard University Press, Cambridge, Mass.
317. Science and Engineering Indicators (2004), "R&D *Investments by Multinational Corporations*", National Science Foundation, Division of Science Resources Statistics, Arlington, VA (NSB 04-01).
318. Science Technology Industry, Special Issue on "Public/Private Partnerships in Science and Technology", Review No. 23, OECD, 1998.
319. Schwartz, Gerd and Benedict Clements, (1999), "Government Subsidies", Journal of Economic Surveys, 13(2), 119-147.
320. Scott, John T., (1984), "Firm versus industry variability in R&D intensity", in Zvi Griliches ed., R&D, Patents, and Productivity (Chicago: University of Chicago Press).
321. Scott, J.T., (1988), "Diversification versus Co-operation in R&D Investment", Managerial and Decision Economics, 9, pp. 173-186.
322. Segal Quince & Partners, (1985), "The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town", Segal Quince & Partners, Cambridge.
323. Sellenthin, M.O (2004), "Universities in Innovation Networks: The impact of supporting infrastructure on the incentives of researchers".
324. Shane, S., S. Venkataraman, (2000), "The promise of entrepreneurship as a field of research", Acad. Management Rev 25(1) 217-226.
325. Shane S., (2002), "Selling University Technology: Patterns from MIT", Management Science, 48(1), p.122-137.
326. Shirai, I. and F. Kodama (1989), "Analysis of the Participants of R&D Consortia"(in Japanese), National Institute of Science and Technology Policy, Report No 5, Science and Technology Agency of Japan.
327. Siegel D., Waldman D., Link A. (2000),"Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Explanatory Study", paper presented at the *The Eighth International Joseph A. Schumpeter Societ Conference –The Millennium Conference Change, Development and Transformation: Trandisciplinary Perspectives on the Innovation Process, Manchester/UK 28th June-1st July 2000*
328. Simon, S., (1999), "Recent Developments in State Aid Policy", chapter 3 in European Economy, 1999 No. 3.
329. Slotboom, Marco M., (1995), "State Aid in Community Law: A Broad or Narrow Definition?", European Law Review, 20(3), 289.

330. Snape, Richard H., (1991), "International Regulation of Subsidies", World Economy, 14, 139-164
331. Spense, M. (1984), "Cost Reduction, Competition, and Industry Performance", Econometrica, 52, 101-121.
332. Stoneman P. (Editor) (1995), "Handbook of the Economics of Innovation and Technological Change" Basil Blackwell Ltd., Oxford.
333. Suzumura, K., (1992), "Cooperative and Non-cooperative R&D in an Oligopoly with Spillovers", American Economic Review, 82, pp. 1307-1320.
334. Smith, K.G., S.J. Carroll and S.J. Ashford (1995), "Intra-and Interorganizational Co-operation: Toward a Research Agenda", Academy of management Journal, 38, pp. 7-23.
335. Stephan , P.E. (1996), "The Economics of Science", Journal of Economic Literature, Vol. XXXIV, No. 6, 1199-1235.
336. Storey, D. (2002), "Six Steps to Heaven: Evaluating the Impact of Public Policies to Support Small Business in Developed Economies", in: International Journal of Entrepreneurship Education, Vol. 1, No. 2, pp. 181-202.
337. Streicher G, Schibany A and Gretzmacher N. (2004),"Input Additionality Effects of R&D Subsidies in Austria-Empirical Evidence from Firm-level Panel Data-tip", Institute of Technology and Regional Policy-Joanneum Research.
338. Symeonidis, G. (2002 a), "The Effects of Competition: Cartel Policy and the Evolution of Strategy and Structure in British Industry", Cambridge, MA: MIT Press.
339. Symeonidis, G. (2002 b), "The Effect of Competition on Wages and Productivity: Evidence from the UK", mimeo, University of Essex.
340. Takayuki Hayashi, (2003), "Effect of R&D programmes on the formation of university–industry–government networks: comparative analysis of Japanese R&D programmes", Research Policy 32, 1421-1442.
341. Tassey, G. (1998), "Comparisons of U.S. and Japanese R&D Policies", Special Report, Strategic Planning and Economic Analysis Group, National Institute of Standards and Technology.
342. Teece, D. (1981), "The market for know-how and the efficient international transfer of technology", ann. Amer. Acad. 458 81-96.
343. Teece, D., G. Pisano, A. Shuen, (1997), "Dynamic capabilities and strategic management", Strategic Management J. 18(7) 509-533.
344. Teece, David, (2002), "A comparative analysis of R&D in public and private organizations and the effects of recent public policy activity in U.S." University of California Berkeley.
345. Terleckyj, Nestor E., (1985), "Measuring economic effects of federal research and development expenditures, recent history with special emphasis on federal R&D performed in industry (Paper prepared for the Workshop on the Federal Role in Research and Development, National Academies of Science and Engineering, Washington DC).
346. Thursby, J., S. Kemp, (2002), "Growth and productive efficiency of university intellectual property licencing", Res. Policy.
347. Toivanen, O. and P. Niininen (1998), "Investment, R&D, subsidies and credit constraints", Working Paper, Dep. of Economics, MIT and Helsinki School of Economics.
348. Toole, Andrew A., (1999), "The contribution of public science to industrial innovation: an application to the pharmaceutical industry", (Stanford Institute for Economic Policy Research Working Paper, Stanford University).
349. Turok, I. (1991), "Policy evaluation as a science: a critical assessment", in Applied Economics, Vol. 23, pp. 1543-1550.
350. UNESCO, (1978), "Recommendation Concerning the International Standardization of Statistics on Science and Technology", Paris,.
351. UNESCO, ISCED (International Standard Classification of Education), (1997), Paris.
352. UNICE (2004), "Review of the Community Framework for State Aid for Research and Development", UNICE Comments, Position Paper.

353. UNICO, "UK University Commercialisation Survey: Financial Year 2003", August 2004.
354. United Nations, (1968), "A System of National Accounts", Studies in Methods Series F, No. 2, Rev. 3, New York.
355. United Nations, (1990), "International Standard Industrial Classification of All Economic Activities", Statistical Papers Series M, No. 4, Rev. 3, New York.
356. U.S. General Accounting Office (GAO) (1989), "Federal Research: Assessment of Small Business Innovation Research Programs", GAO/RCED-89-39, Washington, D.C.: US Government Printing Office.
357. U.S. General Accounting Office (GAO) (1992), "Federal Research: Small Business Innovation Research Shows Success but Can be Strengthened", GAO/RCED-92-37, Washington, D.C.: US Government Printing Office.
358. U.S. General Accounting Office (GAO) (1995), "Federal Research: Interim Report on the Small Business Innovation Research Program", GAO/RCED-95-59, Washington D.C.: US Government Printing Office.
359. U.S. General Accounting Office (GAO) (1997), "Measuring Performance: Strengths and Limitations of Research Indicators", GAO/RCED-97-91, Washington D.C.: US Government Printing Office.
360. Van der Vlist, A., Gerking, S., Folmer, H., (2004), "What Determines the Success of States in Attracting SBIR Awards", Economic Development Quarterly, Vol. 18, No 1, February 2004, p. 81-90.
361. Vanhalewyn, E., (1999), "Trends and patterns in State aids", chapter 2 in European Economy, 1999 No. 3
362. Van Pottelsberghe De La Potterie, B. and A. Panitch (1997), "An insight into the Determinants of the Private R&D Response to R&D Subsidies", in H. Mueller, J.-G. Person and K.R. Lumsden (eds), Management of Technology VI, SMR Sweden, pp.388-398.
363. Van Pottelsberghe B, Nysten S and Megally E (2003), "Evaluation of current fiscal incentivesfor business R&D in Belgium", Solvay Business School, ULB.
364. Vendug, E. (2000), "Public Policy and Programme Evaluation", Transaction Publishers, London.
365. Venetoklis, T., (1998), "Evaluation and Monitoring of Business Aid in Finland. Applicant Enterprises Projects and Distributors of Aid in Industrially Declining Regions. A Quantitative Approach, Government Institute for Economic Research, Helsinki.
366. Venetoklis, T., (1999), "Process evaluation of Business Subsidies in Finland. A Quantitative Approach", Government Institute for Economic Research, Helsinki.
367. Venetoklis, T., (2000), "Methods Applied in Evaluating Business Subsidy Programs: A Survey", Government Institute for Economic Research, Helsinki.
368. Venetoklis, T., (2002), "Public Policy Evaluation: Introduction to Quantitative Methodologies", Government Institute for Economic Research, Helsinki.
369. Verbeek, A., K. Debackere, M. Luwel, P. Andries, E. Zimmermann, F. Deleus (2001), "Linking Science to Technology: Using Bibliographic References in Patents to Build Linkage Schemes", Proceedings of the 78th International Conference on Innovations and Intellectual Property: Economics and Managerial Perspectives, Brussels
370. Verhaar, H.T. (2003), "De staatssteunregimes voor onderzoek en ontwikkeling in de EU, de VS en Japan", Internal Paper, Ministry of Economic Affairs den Hague.
371. Vickers, J. (1986), "The evolution of Industry Structure when there is a Sequence of Innovations", Journal of Industrial Economics, 35, 1-12.
372. Vives, X., (1999), "Oligopoly Pricing: Old Ideas and New Tools", MIT Press.
373. Vives, X., (2004), "Innovation and Competitive Pressure", CERP, 4369
374. Vonortas Nicholas S., (1999), "US Policy Towards Research Joint Ventures", FEEM Working Paper No. 14.2000
375. Wallsten, Scott J., (2000), "Do government-industry R&D programs increase private R&D?: The Case of the Small Business Innovation Research Program", (Department of Economics Working Paper, Stanford University).

376. Wallsten, S.J. (2000), "The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program", The Rand Journal of Economics, Vol. 31, No. 1, Spring 2000, pp. 82-100.
377. Warda, J. (1998), "Measuring the Cost of R&D Tax Incentives", paper presented at the OECD Blue Sky, Workshop on Measuring Innovation, Paris.
378. Warda J., (2001), "Measuring the value of R&D Tax Treatment in OECD Countries", OECD STI Review No. 27.
379. Wessner, Charles W., (2003), "Innovation Award Programs in the US", presentation at Policies and Programs to Build Entrepreneurship, December 15, 2003.
380. Whitehouse, E. (1996), "Tax Expenditures and Environmental Policy", in OECD (1996), Subsidies and Environment: Exploring the Linkages, OECD, Paris, pp. 67-69.
381. Wissenschaftsrat, (1975), "Empfehlungen des Wissenschaftsrates zur Organisation, Planung und Förderung der Forschung", Köln: Wissenschaftsrat
382. Wissenschaftsrat, 1988, "Empfehlungen des Wissenschaftsrates zu den Perspektiven der Hochschulen in den 90er Jahren", Köln: Wissenschaftsrat.
383. World Bank (1998), "1998 World Development Report", Washington, D.C.
384. WTO, Subsidies and Countervailing Measures Agreement, Articles 5, 6, 7 and 8.
385. Young, Alison, (2002), "Improving Measures of Government Support to Industrial Technology", OECD STI Review, Special Issue on New Science and Technology Indicators, No 27, p. 147-184

List of Websites

1. http://www.atp.nist.gov/atp/overview.htm
2. http://tpc-ptc.ic.gc.ca/epic/internet/intpc-ptc.nsf/en/Home
3. www.cordis.lu/innovation
4. *http://trendchart.cordis.lu/*
5. http://www.europa.eu.int/
6. *http://www.europa.eu.int/comm/competition/state_aid/register/ii/*
7. www.wto.org
8. http://www.garching-innovation.de
9. http://www.pst.fraunhofer.de
10. http://www.helmholtz.de
11. http://www.ascenion.de
12. http:www.casti.co.jp
13. http://www.nsftokyo.org/rm04-05.html
14. http://www.rieti.go.jp/users/cluster-seminar/pdf/003_p_en.pdf