Raising EU R&D Intensity

Improving the Effectiveness of the Mix of
Public Support Mechanisms for Private Sector
Research and Development

Report to the European Commission
by an Independent Expert Group

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Directorate-General for Research
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Director : Jean-François Marchipont
Head of Unit : Isi Saragossi
Scientific Officer for further information on this project :
Arie van der Zwan, e-mail : arie.van-der-zwan@cec.eu.int
Web site: http://europa.eu.int/comm/research/era/3pct

Foreword

The EU is currently lagging behind both the USA and Japan in terms of expenditure on R&D as a proportion of GDP, primarily due to slow relative growth in business R&D expenditure. The European Council set an overall target of 3% of GDP by the year 2010, with industry asked to contribute two thirds of this objective. To approach these levels, dramatic improvements are needed in the effectiveness of policies used to stimulate private sector R&D.

In order to review how progress could be made towards this goal, the Commission services set up four expert groups to explore and enhance the potential of different financial and fiscal policy instruments. These different expert groups investigated respectively: direct measures, fiscal measures, risk capital measures and loan and equity guarantee instruments. An overarching Expert Group, the policy mix group, was also charged with reviewing the relationships between the mechanisms dealt with by the four groups and considering how these measures might be combined most appropriately to stimulate private sector R&D.

The substantial increases that are necessary are only likely to come about if the right combinations of policies are used to tackle the very different sets of problems which Member States and regions face within the EU.

The specific aim of this report is to offer suggestions and guidance concerning the construction of policy mixes capable of raising private sector R&D intensity in the EU to the required levels. Starting with an analysis of R&D investment patterns and behaviour in the EU and elsewhere, the report goes on to consider the range of policy instruments available to tackle the problem of the R&D investment gap, focusing in particular on financial and fiscal instruments but also covering a range of other policies affecting the framework conditions for R&D and technological innovation in the EU. After reviewing the use of these instruments, both in isolation and combined in a variety of policy packages or mixes, the report then presents a series of recommendations for policymakers across the EU.

I should like to thank all the experts who took part in the production of this timely report, particularly the Chairman of the expert group, Mr. Guy. Their work contributed significantly to the Commission's own thinking and to the preparation of the Communication from the Commission: 'Investing in Research: An Action Plan for Europe'. It contains much of value to all those concerned with the formulation and delivery of effective policy mixes. As such I trust that it will stimulate the process of mutual learning needed to realise not only the 3% target for R&D, but also the target set at Lisbon of becoming the most competitive and dynamic knowledge-based economy in the world.

This report, as well as the reports of the other Expert Groups, is available on the Commission Web site http://europa.eu.int/comm/research/era/3pct.

Philippe Busquin
European Commissioner for Research

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The Expert Group

Chair

Ken Guy, Wise Guys Ltd., 6 Erringham Road, Shoreham-by-Sea, BN43 5NQ, UK

Rapporteur

Lena TSIPOURI, University of Athens, Department of Economic Science, 5 Stadiou Street, Athens, GR-10562, GREECE

Members of the Expert Group

Patries BOEKHOLT, Technopolis B.V., Keizersgracht 62, Amsterdam, NL-1015 CS, NETHERLANDS
Winfried BRAUMANN, Frauenthal Holding A.G., Prinz-Eugen-Strasse 30/4a, Vienna, A-1040, AUSTRIA
Alan DORAN, IMM, Downgate House, 25 Wharf Road, Shillingford, UK-OX10 7EW, UNITED KINGDOM
Rory EARLEY, Westport Private Equity, The Portergate, 257 Ecclesall Road, Sheffield, UK-S11 8NX, UNITED KINGDOM
Luke GEORGHIOU, PREST, University of Manchester, Oxford Road, Manchester, UK-M13 9PL, UNITED KINGDOM
Erkki ORMALA, NOKIA Corporation, PO Box 226, FIN-00045 NOKIA GROUP, FINLAND
Bruno VAN POTTELSBERGHE, Solvay Business School, ULB-CP145/01, 21 Avenue F. D. Roosevelt, Brussels, B-1050, BELGIUM
Jacques SERRIS, Ministère Délégué à la Recherche et aux Nouvelles Technologies, Direction de la Technologie, 1, rue Descartes, Paris 05, FR-75231, FRANCE
Jerry SHEEHAN, OECD Science and Technology Policy Division, 2 rue André-Pascal, Paris, FR-75775, FRANCE
Xavier THEUNISSEN, Ministry of Economic Affairs, Bezuidenhoutseweg 20, PO Box 20101, Den Haag, NL-2500 EC, NETHERLANDS
Sigurt VITOLS, Wissenschaftszentrum Berlin für Sozialforschung, Greifenhagener Str. 57, Berlin, D-10437, GERMANY

Experts Assisting the Group

Doris AGNETER, Raiffeisen Centrobank AG, Tegetthoffstraße 1, Vienna, A-1015, AUSTRIA
John RIGBY, PREST, University of Manchester, Oxford Road, Manchester, UK-M13 9PL, UNITED KINGDOM

Commission Staff Responsible

Isi SARAGOSSI, Head of Unit, DG RESEARCH
Sean O'REAGAIN, DG RESEARCH

Executive Summary

The EU will not hit the 3% target for R&D as a proportion of GDP by 2010 unless drastic action is taken to stimulate private sector R&D expenditure. Industry is expected to spend up to 2% of GDP on R&D by 2010, but this level will not be attained without support from governments and the European Commission along many fronts. In particular, although conventional R&D policies and financial and fiscal R&D policy instruments have a critical role to play in providing this support, they will need to be complemented by additional policies that affect, amongst other things, the supply of researchers, the demand for innovative goods and services, and the general health of national and regional innovation systems across the length and breadth of the EU.

Drastic measures along a broad front are needed for two main reasons. First is the nature and scale of the problem. If the EU is to match the R&D funding levels of the USA as a proportion of GDP, industrial restructuring is required, with the balance shifting from economies dominated by low- to medium-tech SMEs to ones in which global MNCs interact with a rich mix of research-oriented institutions and R&D-intensive firms of different sizes in new and rapidly expanding lead markets. Second, a broad spectrum of policy measures is necessitated because R&D expenditure levels are vitally dependent on the health and dynamism of the overall innovation systems in which firms operate, and many of these across the EU are currently not strong enough to support increased R&D levels. In particular, demand is weak and the supply of researchers too low.

The precise mix of policies will vary from one setting to another within the EU, but in all settings there will be a need to construct holistic policy portfolios containing a variety of focused packages of financial and fiscal R&D support instruments and other measures affecting the general environment in which industrial R&D takes place. These include, for example, measures addressing overall macroeconomic conditions and financial and labour markets; changes in competition policy and a host of regulatory regimes affecting innovation, trade and industrial development; educational measures influencing the supply of researchers and levels of entrepreneurship within society; and, critically, support for R&D in public sector institutions.

Four routes in particular will need to be contemplated by policymakers attempting to raise R&D levels across the EU. In the short term, the route likely to lead to the most dramatic increases in R&D involves making the EU an attractive place for R&D-intensive MNCs to grow or relocate R&D capacity. R&D is also likely to be considerably enhanced in the longer term by efforts to create a favourable environment for the creation and support of dynamic, R&D-intensive SMEs in new and existing high-technology areas with a high potential for growth. Other routes include boosting R&D activities within existing moderately R&D-intensive firms, and expanding the R&D community by enabling non-R&D performers to enter the fold.

For each of these routes a wide variety of policy mechanisms should be deployed. For the routes involving the creation of new R&D intensive SMEs and the initiation of R&D activities in non-R&D performers, catalytic risk capital and guarantee instruments and measures supporting information exchange and networking are central to the task. In contrast, direct measures such as support for R&D projects and public technology procurement can combine with indirect fiscal measures to form a critical policy focus for increasing existing R&D investment within many of the medium- to high-tech R&D performers. In terms of attracting MNCs, however, policies affecting framework conditions such as the quantity, quality and accessibility of researchers and efforts to reduce the regulatory burden on firms operating in different product markets will be as, if not more, important than most financial and fiscal measures.

Which policy mixes are chosen and which routes selected will depend on the specific problems faced in different contexts. In some of the larger and more mature economies in the EU, it will be necessary to take all routes. Most of the R&D currently undertaken in the EU is conducted in these countries, and the aggregate 3% target will certainly be missed if these economies do not raise R&D levels substantially. Because of their mature innovation systems and associated policymaking experience, however, these Member States are in a good position to evolve strategies for all four routes.

In contrast, some of the cohesion and accession countries are not so well placed. There are fewer world-class centres of academic excellence to act as growth poles for regional development; relatively meagre concentrations of industrial R&D performers; and weak demand for innovative goods and services. Efforts here might therefore focus on policy combinations which couple multiple financial and fiscal R&D support measures in a few carefully selected industrial sectors with a strong focus on policies capable of stimulating demand and absorptive capacity in the economy generally.

Careful analyses of strengths, weaknesses, opportunities and threats are needed if appropriate policy mixes are to be chosen. In turn, this depends on the strategic intelligence available to policymakers, and vast improvements are needed in this sphere if wise decisions are to result. In particular, better data are required on the spread of industrial R&D activities both within and across Member States; better systems of evaluation are needed to assess the efficacy of different policy mechanisms; more foresight exercises are necessary in order to review and discuss options and opportunities; and learning via the sharing and benchmarking of comparative performance and best practice needs to be greatly improved.

The choice of individual financial and fiscal R&D support measures depends on their specificity, or fit for purpose, and their potential impact. These vary greatly from one instrument to another. Separate reports reviewing these aspects, together with hints and tips concerning good practice, fresh approaches and guidelines for the future, were produced by a series of Expert Groups and are summarised in this report. The hope is that these reviews can be of some assistance to policymakers when contemplating the use of different types of measure and constructing policy mixes.

Similarly, this report also contains an overview of some of the main framework conditions and associated policies that affect R&D and innovation activities, together with many recommendations intended to strengthen EU innovation systems and raise private sector R&D levels. Again the hope is that these suggestions can inform the choices made by policymakers across the EU. The most important of these, however, is addressed to the European Council. Although setting a target for R&D intensity at Barcelona was a welcome first step that has stimulated much constructive policy thinking, it now needs to be complemented by further actions focusing on improvements elsewhere in the EU innovation system. In particular, the European Council needs to be aware that setting and attaining additional innovation system targets related to the supply of researchers, the exploitation of R&D and the diffusion of innovations are necessary next steps if both the Barcelona and Lisbon targets are to be reached.

1.0 Introduction

The Lisbon European Council meeting of March 2000 set the European Union (EU) the goal of becoming the most competitive and dynamic knowledge-based economy in the world. At a further meeting in Barcelona in March 2002, in a context of concern over the growing disparity between research and development (R&D) investment levels in the EU compared with the USA and Japan, R&D was situated at the heart of the development strategy via new targets for EU R&D investment, with aggregate levels set to rise from 1.9% of GDP towards 3% of GDP by 2010. The Council also suggested that the private sector should provide two thirds of the needed R&D investment.

The task of raising industrial R&D investment levels is primarily the responsibility of industry itself. There is still a role for the public sector to play, however, and many areas where the responsibility can be shared. A series of Expert Groups were thus set up by the European Commission to explore and enhance the potential of public policy instruments to stimulate private sector R&D investment levels. These levels are affected by a variety of framework conditions and policies governing business behaviour generally and R&D and innovation activities in particular, but there was **a specific interest in financial and fiscal measures affecting the private sector's access to, and use of, finance for R&D**. These measures fall into the three categories shown in Exhibit 1.1 and described further both below and in Exhibit 1.2:

- **Direct Financial R&D Measures** involve the direct transfer of financial support for R&D from the public to the private sector via grants, conditional loans etc.;
- **Indirect Fiscal R&D Measures** (often shortened to Indirect or Fiscal measures) involve the public sector forsaking tax income from the private sector in exchange for approved R&D investment behaviour;
- **Catalytic Financial R&D Measures** are actions taken by the public sector that help R&D performers access external private sector sources of finance – which can then be used either to finance R&D directly or to generate profit, some of which will be re-invested in R&D. Typical Catalytic Measures are:
    - **Risk Capital Measures**, i.e. measures taken by the public sector which catalyse the flow and use of risk capital for both R&D and innovation-related activities likely to increase R&D investment levels in the future;
    - **Loan and Equity Guarantee Measures**, i.e. measures whereby the public sector tries to encourage additional investment in R&D by offering to share part of the risk involved in the provision of support for R&D and innovation-related activities.

Exhibit 1.1 Financial and Fiscal Measures to Raise R&D Investment Levels

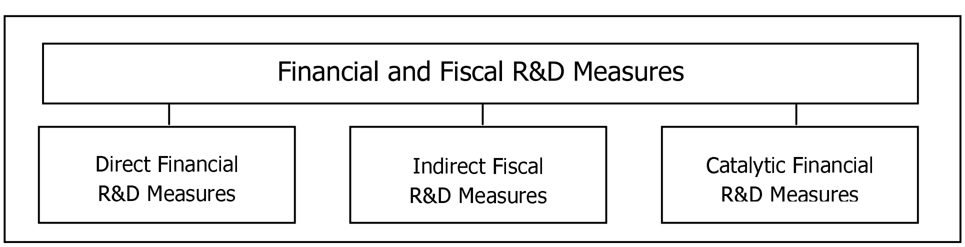
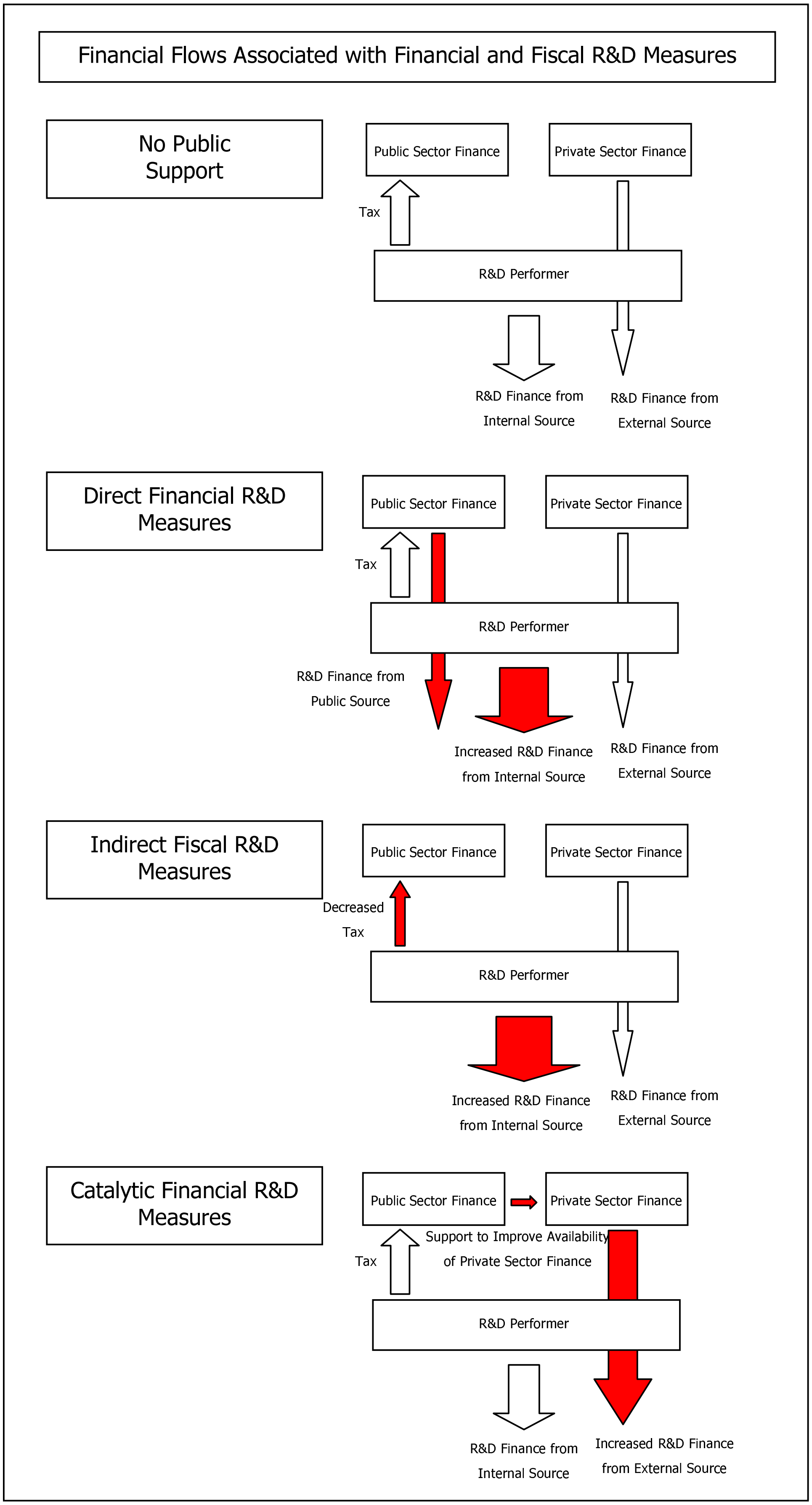


Exhibit 1.2 Financial Flows Associated with Financial and Fiscal Measures



The four Expert Groups constituted by the European Commission were thus asked to explore the potential of:

- **Direct Measures**;
- **Indirect Fiscal Measures**;
- **Risk Capital Measures**;
- **Loan and Equity Guarantee Measures**.

A fifth Expert Group, the **Policy Mix Expert Group**, was set up to coordinate the activities of the other groups and provide a common methodological framework. Specifically, its remit was firstly: "to identify how public financial support mechanisms can contribute more effectively, both individually and in combination, to stimulating private investment in research"; and secondly to offer recommendations concerning the constitution of appropriate policy mixes in different contexts.

A key task of the Policy Mix Expert Group was to synthesise the work of the other Expert Groups and focus on the potential of the four types of financial and fiscal instruments when used both alone and in combination. However, during its early deliberations, the Policy Mix Expert Group decided to preface this work with an analysis of the dimensions and causes of the growing gap in R&D investment levels between the EU and elsewhere, and with a review of the nature and potential of a broad range of policy instruments to affect R&D investment levels. These efforts are reflected in Section 2 of this report.

These initial analytical efforts convinced the Policy Mix Expert Group that the financial and fiscal instruments being studied in depth by the other Expert Groups had an important part to play in the stimulation of private sector R&D investment levels when used either individually or in combination with each other. Nevertheless, the Policy Mix Expert Group also concluded that their potential impact was modest compared with the potential of policy mixes which involved not only these instruments but also an expanded set of instruments spanning policy spheres as diverse as education, public procurement and competition – all of which affect the framework conditions within which firms operate and within which R&D investment decisions are taken.

Underpinning this conclusion was the conviction, based on theoretical and empirical considerations, that concerted, interdependent policy efforts to improve the wholesale functioning of innovation systems in the EU would have a far greater impact on eventual R&D investment levels than the autonomous and independent use of financial and fiscal instruments alone. In particular, even though efforts to improve research capacity are needed within the EU, these have to be complemented by efforts aimed at improving the quantity and quality of human capital, the technological and innovation performance of firms and, especially, the absorptive capacity of markets for technological goods and services. The resolution of deficiencies in these areas and the creation of a well functioning innovation system will then create a virtuous demand for R&D and stimulate R&D investment accordingly.

Consequently, Section 3 of this report covers what we have termed 'Holistic Policy' solutions while Section 4 concentrates on 'Focused Policy' solutions. Holistic Policy solutions to the problem of raising R&D investment levels are those which involve policy actions along a diverse front, while Focused Policy solutions – a subset of holistic measures – are those specifically involving the four types of financial and fiscal instruments reviewed by the other Expert Groups. Although not the main area of concern of the activities of the Policy Mix Expert Group, Holistic Policy solutions are treated first because of the importance attached by the group to the use of holistic solutions generally. Precisely because they fall outside the specific remit of the group, however, they are treated in a more superficial manner than they deserve. Only a very broad brush is thus used to portray the main elements of the picture, illustrating the connections between different components and suggesting ways in which the picture can be developed in the future.

In contrast, Focused Policy solutions involving the use of the four types of financial and fiscal instruments are covered in more detail. Section 4 first takes each instrument in turn and examines aspects such as their specificity, importance and potential impact. This is followed by a discussion of good practice and suggestions for their future use in different contexts. Finally, in Section 5, the use of these instruments in Focused Policy combinations is considered, together with an appraisal of their suitability for inclusion in Holistic Policy packages.

A final Section 6 offers some broad conclusions and recommendations for future policy.

2.0 Understanding the Problem and Framing Potential Solutions

The setting of goals for EU R&D levels at the Barcelona meeting of the European Council constituted formal recognition of the importance of R&D in the drive to become the world's leading knowledge-based economy – the target set at the earlier meeting of the European Council in Lisbon in March 2000. R&D is the main source of innovation in modern economies, and innovation is one of the main drivers of economic growth, productivity gains, economic adjustment and job creation. The R&D target is thus not an end in itself, but an important means of attaining the Lisbon target.

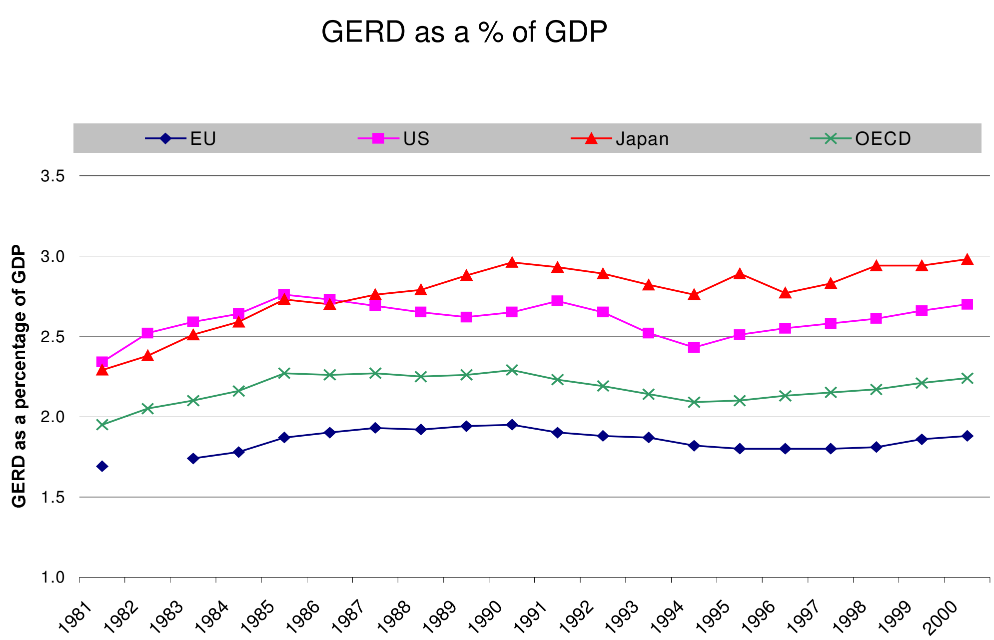
2.1 Scoping the problem

2.1.1 The Importance of Business-oriented R&D

Understanding the scope and scale of the R&D gaps between countries and their variation over time and space is an important first step in the eventual formulation of appropriate policy mixes to remedy perceived problems.

Exhibit 2.1 shows the differences in R&D intensity, measured in terms of gross expenditures on R&D (GERD) as a share of GDP, between the EU, the US, Japan and the OECD region. Clearly there is gap between the EU and its main competitors, with the EU-US gap standing at 0.8 percentage points in 2000. Moreover, the gap between the EU and the US had widened by approximately 0.2 percentage points over the period 1994-2000.

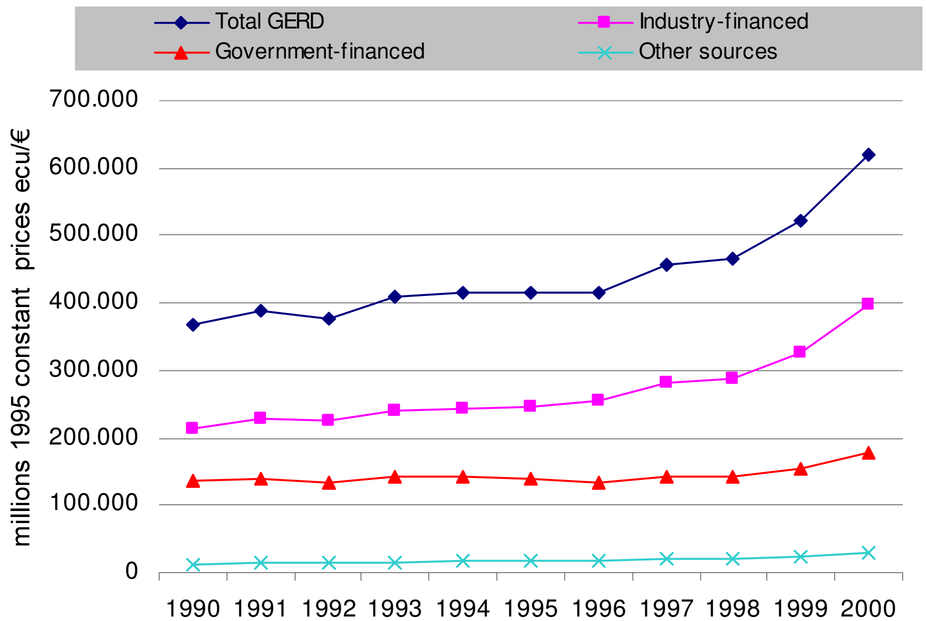
Exhibit 2.1 R&D Intensity in Major OECD Countries and Regions



Source*: OECD*

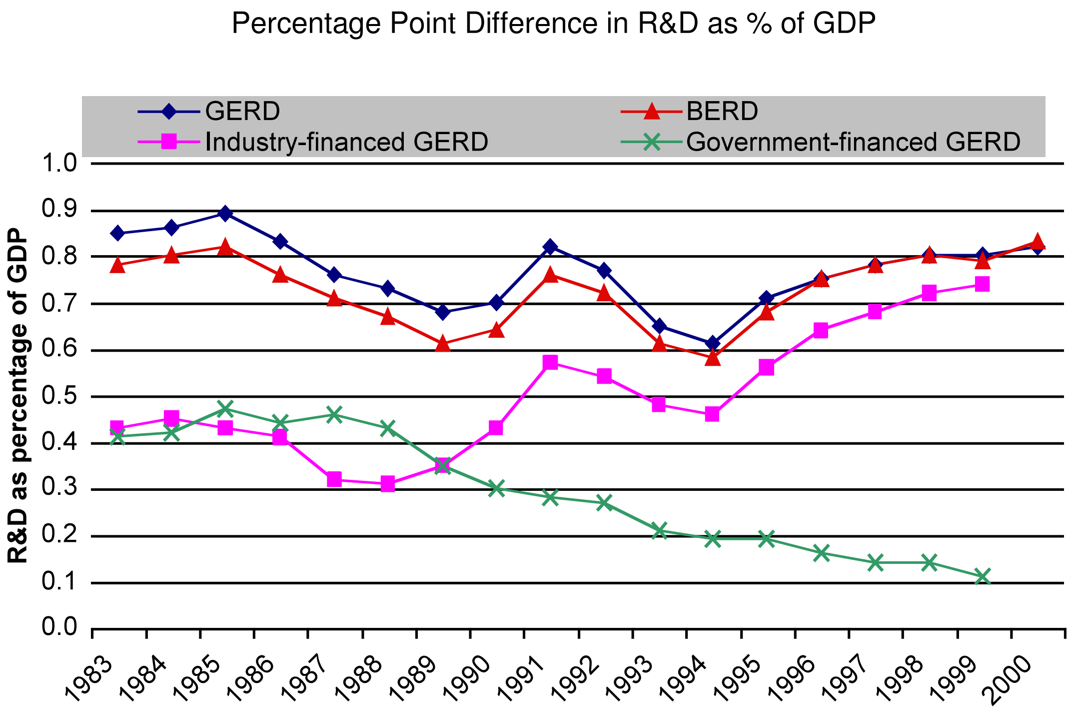
Further analysis of OECD trends (Exhibit 2.2) and the EU-US gap in particular (Exhibit 2.3) reveals that GERD is increasingly dominated by business sector R&D, with government playing a smaller role than hitherto, and that the gap is now almost entirely due to differences in business R&D, whether measured by R&D performed (BERD) or financed by industry (industry-financed GERD). There is a very small gap in Government-financed GERD/GDP, but this is declining, whereas the gaps in terms of business R&D measures are increasing.

Exhibit 2.2 Gross Expenditures on R&D in the OECD Region 1990-2000



Source*: OECD*

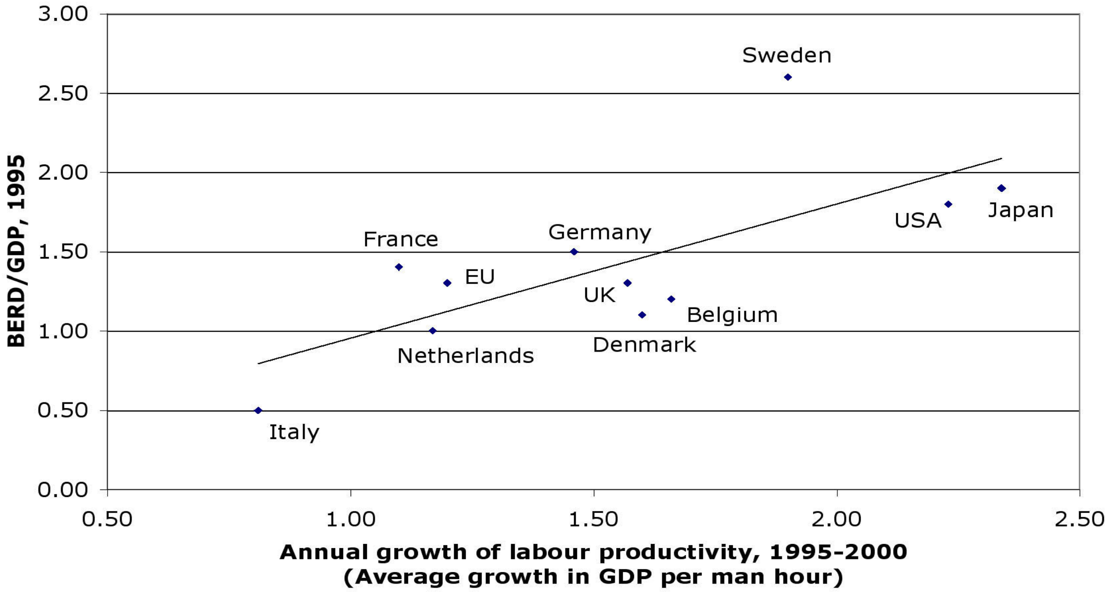
Exhibit 2.3 R&D Gaps between the US and EU



Source: OECD

The significance of this widening gap in business-oriented R&D should also be noted. Soete (2002) (Exhibit 2.4) has demonstrated a positive relationship between business-oriented R&D intensity and productivity growth over the last few years of 'innovation-induced growth'. Any increase in the R&D gap is thus likely to lead to even greater differences between productivity levels in the EU and US.

Exhibit 2.4 Business-oriented R&D Intensity (1995) and Productivity Growth (1995-2000)

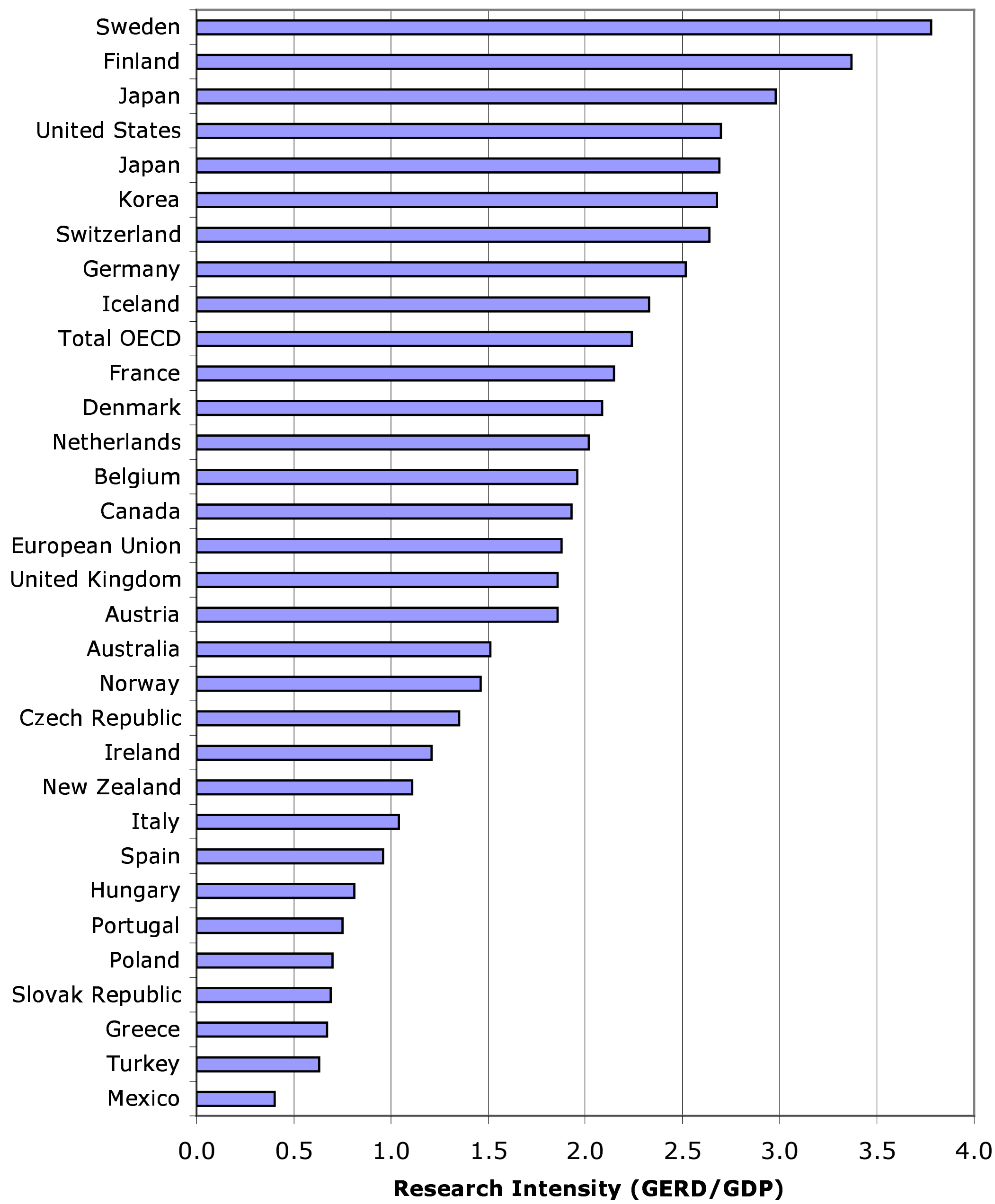


Source*: Soete (2002)*

2.1.2 Economic Size, National Variations and Industrial Structure

The existence of a gap can be explained in part by differences in the size and industrial structure of the US and EU economies. Holbrook (1991), amongst others, has argued that there is a general tendency for R&D intensity to increase with increasing size of national economy. The fact that the EU and US economies are of a similar size would seem at first sight to negate scale as an explanatory factor, but the fact that the EU is really an agglomeration of much smaller economies means that it can't be discounted out of hand. Exhibit 2.5 shows variations in R&D intensity in thirty countries. Sweden and Finland are the only EU countries with higher research intensities than the US as a whole, while the EU figure is depressed considerably by low research intensities in Italy and the cohesion countries – a situation which will undoubtedly be exacerbated once the accession countries become part of the EU, since none of them has a R&D intensity higher than the EU average.

Exhibit 2.5 R&D Percentage of Gross Domestic Product 2000 (or most recent year)

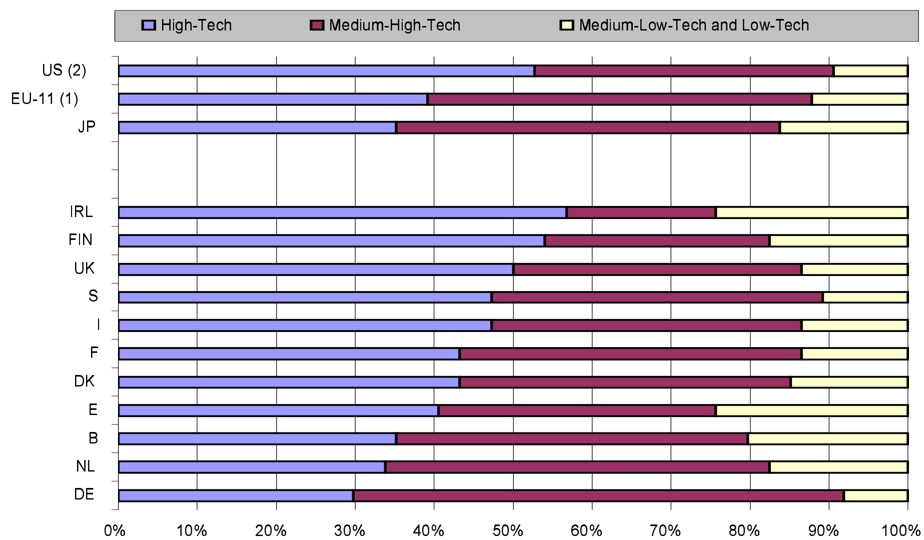


Source: OECD

Differences in industrial structure provide another explanation for the existence of a gap in business R&D intensity between the US and the EU. High-tech industries account for a larger share of total output in the US than in the EU generally and for a larger share of the R&D performed (Exhibit 2.6). The relatively greater importance of the IT sector in the US, for example, is demonstrated by the fact that the 'Office, accounting and computing machinery' sector accounted for 11.6% of industrial R&D in 1997, while comparable figures in the EU were 2.3% in Germany, 2.4% in France and 1.2% in the UK (NSF, 2002). The US also has a greater share of the world's top R&D spenders than the EU (202 out of the top 500 are US-owned, compared to 137 European-owned companies (DTI R&D Scoreboard, 2002). In this top 500, there are 58 US IT

Hardware companies compared with 11 European, and 29 US Software and IT Services companies compared with 7 European firms. Moreover, Exhibit 2.7, which compares business R&D as a share of GDP by industry sector for the US and the EU (Sheehan, 2002), shows clearly that the ICT and Services sectors account for most of the difference between business R&D intensity levels in the two blocs. Growth in business R&D intensity in the US was also largely driven by growth in the high-tech IT and service sectors during the 1990s (Exhibit 2.8), though this growth has faltered since the dot.com bubble burst. Growth in R&D intensity in the IT sector was also strong in Finland, Sweden and Ireland, but very low in Germany and negative in the UK. In comparison, Business R&D intensity dropped in 'Other manufacturing' in the US, UK, Japan, Germany and the EU as a whole.

Exhibit 2.6   Share of BERD in the Manufacturing Sector by Technology Intensity
1999 (or most recent year)

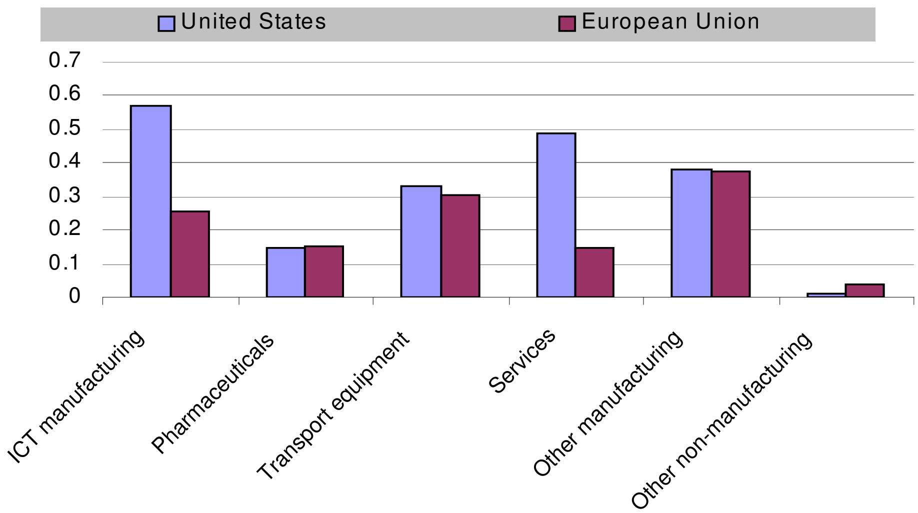


Notes: *(1) EL, L, A, P are not included in EU-11*

(2) US: Ships (Medium-Low-Tech) are included in other transport (Medium-High-Tech)

Source: DG Research; Data: OECD

Exhibit 2.7 Comparison of Business R&D as a Share of GDP in the US and EU by Industry Sector



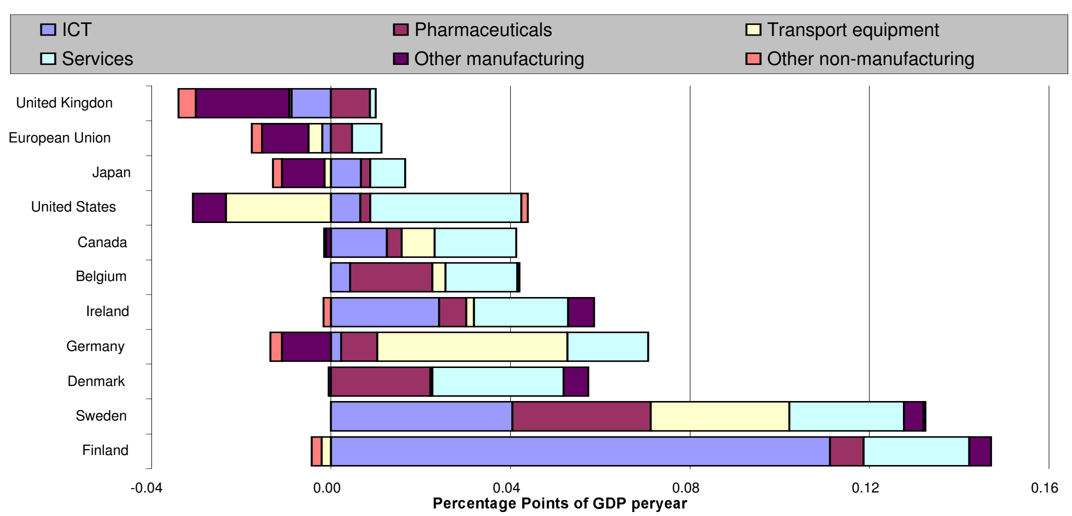
2000 (or most recent year)

R&D expenditure as % GDP

Note: IT manufacturing includes office, computing and accounting machines; communications equipment; and electronic components.

Source: OECD

Exhibit 2.8 Average Annual Increase in Business R&D Intensity by Industry Sector



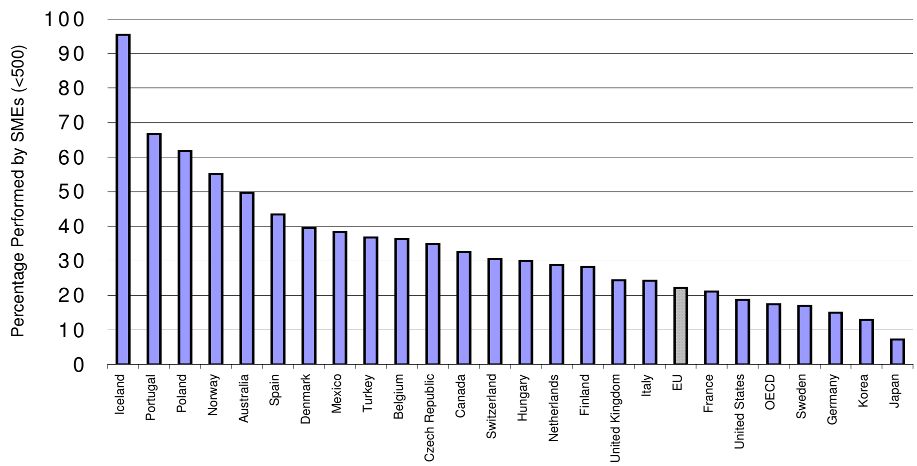
1990-2000 (or nearest years)

Note: IT manufacturing includes office, computing and accounting machines; communications equipment; and electronic components

Source: OECD

Differences in sectoral composition – in particular the comparative size and importance of the IT sector and the proportion of high-tech firms in the overall population – account for the greater part of the gap in business R&D intensity between the EU and US. The proportion of overall R&D carried out by firms of different size is another related factor. In the US, R&D performing large firms (defined here as firms with greater than 500 employees) accounted for 81.4% of industry R&D in 1999 (NSF, 2002). In Europe, Exhibit 2.9 shows that the proportions accounted for by large firms was smaller – often much smaller – in all EU countries other than Sweden and Germany. Moreover, a plot of business R&D intensity (Industry-financed GERD as a percentage of GDP) against the SME[1] share of business R&D (Exhibit 2.10) shows that R&D intensity falls as the SME share of R&D rises – which in turn suggests that one determinant of the gap between the EU and the US is the preponderance of low R&D intensity SMEs throughout many of the EU economies, particularly the smaller economies.

Exhibit 2.9 Total and Government-financed Business R&D Performed by SMEs 1999 (or most recent year)



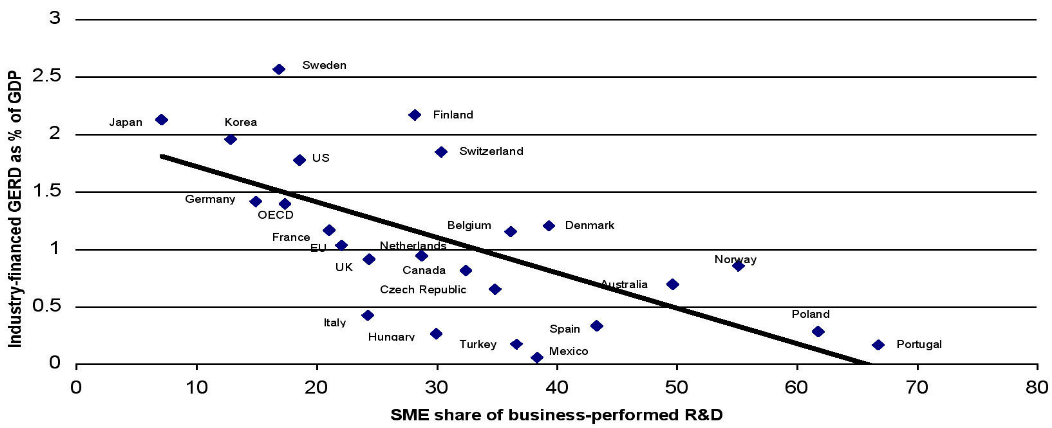
Note: SMEs defined here to have <500 employees

Source: OECD

High-tech SMEs nevertheless have a role to play in determining high R&D intensities, for there is recent evidence that SMEs – in particular new technology based firms (NTBFs) – played a disproportionate role in boosting R&D intensity in the USA in the 1990s. In large part, however, this was possible because of the presence of large firms and their practice of incorporating NTBFs into their supply chains, investing in their R&D (through corporate venture capital), and then often acquiring the companies, thereby providing an alternative exit strategy for venture capitalists that helped attract further VC investments. Efforts to support R&D in the SME population should thus aim not only to provide direct financial support but also to create effective introductions and links to networks anchored by large firms.

[1] N.B. SMEs are typically defined in the EU as having less than 250 employees. The data used in this and some other Exhibits, however, was only available for firms with less than 500 employees.

Exhibit 2.10 Industry-financed GERD as a Percentage of GDP and SME Share of Business R&D 1999 (or most recent year)



Note: SMEs defined here to have <500 employees

Source: OECD

2.1.3 Closing the R&D Gap

Meeting the EU's proposed R&D target will require considerable increases in R&D expenditures. The exact figure will depend on the rate of growth of GDP over the remainder of the decade. Assuming no growth in GDP (an unattractive assumption from the perspective of increased living standards), a 3% R&D intensity target implies total R&D expenditures (GERD) of €245.1 billion – a €91.2 billion increase over 2000 values. The average annual rate of growth in R&D expenditures will have to more than double from the 2% rate that characterised the 1990s to almost 4.8%. If GDP growth is closer to historical levels of 2%, R&D spending will have to grow by €145 billion by 2010, or almost 7% a year (Exhibit 2.11).

The effect on industry-financed GERD (IR&D) would be equally dramatic. With no growth in GDP, IR&D will have to increase to €163 billion between 2000 and 2010 (compared to its level of €85 billion in 2000). At 2% GDP growth, IR&D will need to increase to €199 billion, or nearly 9% annually. This equates to an increase in IR&D over the course of a decade 2.33 times the baseline level in 2000. The ability of firms to boost their expenditures on R&D will also be affected by the rate of GDP growth. Within larger, established firms (which account for most business R&D in high R&D intensity countries)), R&D is funded generally from retained earnings, which makes R&D investment more difficult in periods of slow economic growth. During more rapid economic expansions, growing profits can expand the pool of resources which firms use to finance R&D, but R&D intensity will increase only if R&D spending rises faster than sales (which is entirely possible, given the US experience during the 1990s). Increases in R&D intensity can also result from the creation of new, fast growing R&D-intensive firms, e.g., high-tech start-ups and spin-offs, though new firm creation is more likely during periods of strong economic growth, when the targets for industry-financed R&D (see Exhibit 2.11) are themselves higher.

Exhibit 2.11 Financing the Proposed EU R&D Targets

	Baseline Values (2000 and 1990-2000 Trend line)	Estimated Values in 2010			
		Percentage Annual Growth in GDP			
		0	1	2	3
GDP (millions €)	8,169,287	8,169,287	9,023,975	9,958,315	10,978,839
GERD (millions €)	153,885	245,079	270,719	298,749	329,365
GERD/GDP (%)	1.88%	3.00%	3.00%	3.00%	3.00%
Total growth in GERD (millions €)	28,660	91,194	116,834	144,864	175,480
Annual growth in GERD (%)	1.99%	4.76%	5.81%	6.86%	7.91%
Industry financed GERD (millions €)	85,369	163,386	180,480	199,166	219,577
Industry financed GERD/GDP (%)	1.05%	2.00%	2.00%	2.00%	2.00%
Total growth in industry-financed GERD (millions €)	22,914	78,017	95,110	113,797	134,208
Annual growth in industry-financed GERD (%)	2.75%	6.71%	7.77%	8.84%	9.91%

Note: Does not take expansion of the EU into account. Assumes a target R&D intensity of 3% and a target intensity for Industry-financed GERD of 2%

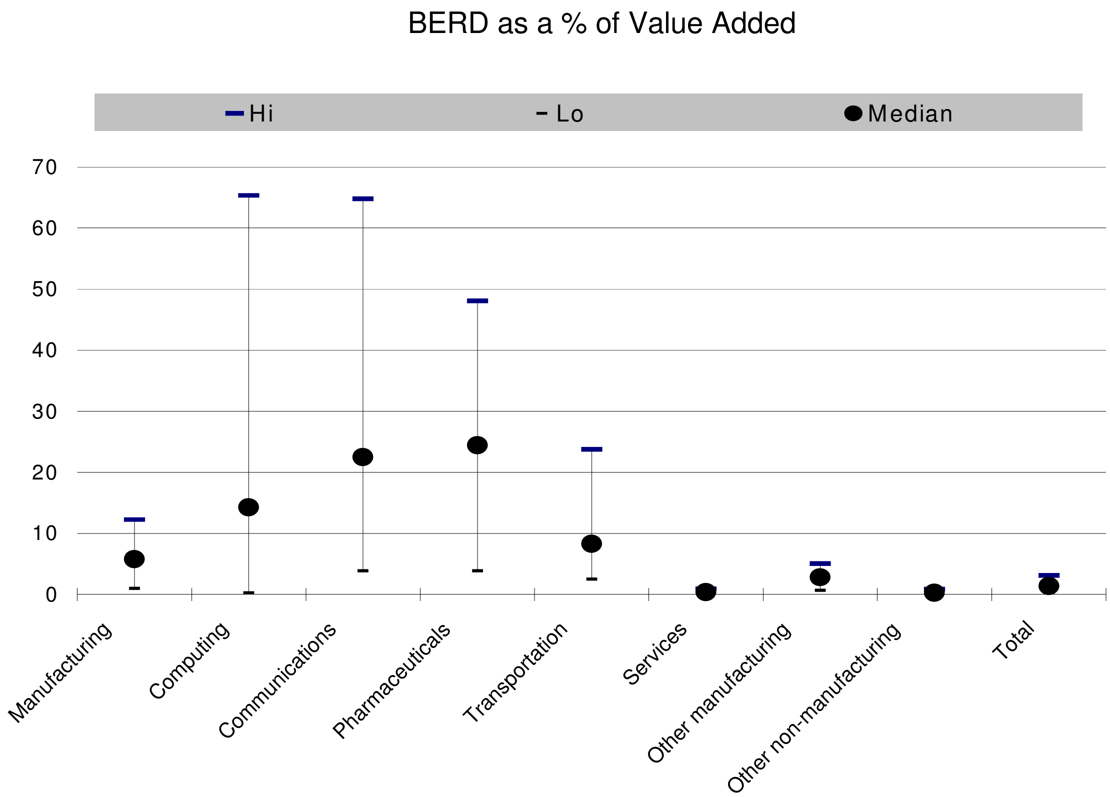
Source: OECD

2.1.4 Industrial Structure Changes

The size of the gap and the rates of growth in R&D expenditure needed to close it are daunting. Moreover, closing the gap will require more than exhortations to existing firms to increase spending by ten percent or more per year. The differences in industrial structure between the US and the EU imply that wholesale restructuring will be needed in the EU – particularly in the smaller economies dominated by low- to medium-tech SMEs – to effect the transition to a high R&D intensity economy. Inevitably this will involve a shift from national economies populated by SME-dominated, low and medium-tech sectors to those with a larger proportion of high-tech firms and large research intensive conglomerates. In Finland, Sweden and the USA, which all have high R&D intensities, more than half of all business R&D is performed in the ICT, pharmaceutical and service sectors, whereas in many other EU countries the proportion is much smaller.

High-tech sectors appear to offer more scope for increasing R&D spending as a share of value added than low-tech sectors (Exhibit 2.12). In the communications sector, for example, the span of values for R&D as a share of value added in OECD countries ranges from a low of 3.8% in Poland to a high of 65% in Sweden, with a median of 22.5%. In other manufacturing industries (all manufacturing less ICT, pharmaceuticals and transportation equipment), R&D as a share of value added has a much smaller range, from 0.6% in Italy to 5.0% in Japan. These figures suggest that shifting industrial activity into high-technology sectors provides an opportunity to raise national R&D intensities to higher levels.

Exhibit 2.12 Range of R&D Intensities across OECD Countries by Industry Sector 2000 (or most recent year)



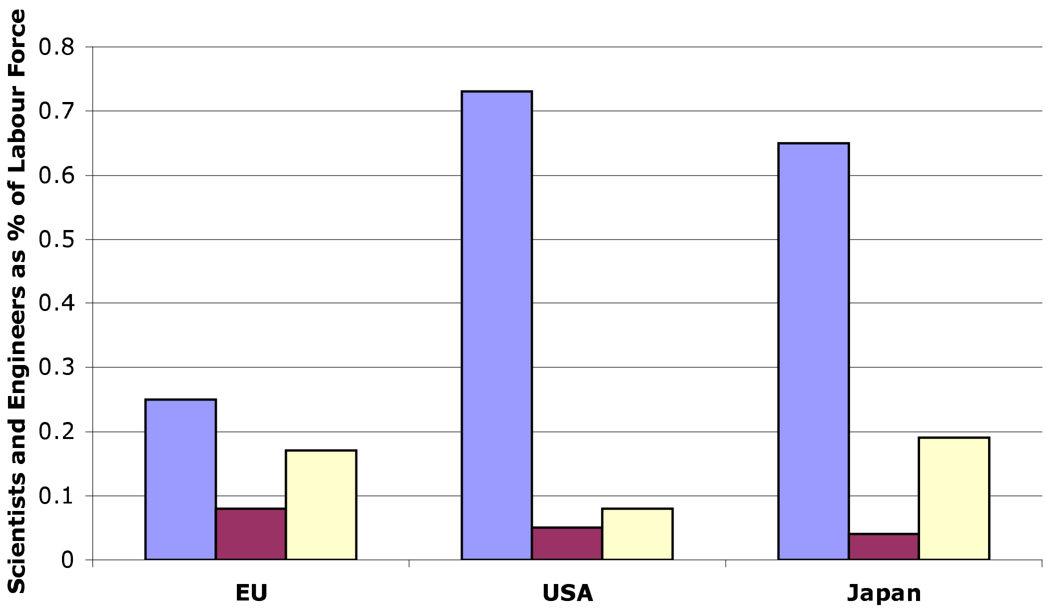
Source: OECD

Achieving significant increases in R&D intensity (R&D/GDP), however, will require that the markets for high-technology goods and services continue to expand. Market growth appears to be a determining factor in boosting R&D intensity. In Finland, for example, R&D intensity in the ICT sector (R&D/GDP) grew by a factor of four as the share of the sector in industrial output more than tripled (as measured by value added as a share of GDP) (Sheehan, 2002). In contrast, countries that experienced only small increases in business R&D intensity during the 1990s tended to see high-technology sectors decline as a share of total industrial output. On the downside, rapid market growth such as that experienced in the ICT sector over the 1990s may not be repeated over the next decade. The ICT market is experiencing a slowdown that seems related, in part, to saturation in many traditional markets; the biotech market faces additional regulatory hurdles, and nanotechnology markets are still nascent. It cannot therefore be assumed that the market growth accompanying a shift to high sectors will be a significant source of increased R&D intensity. It may even be that the rapid growth in R&D intensity in the USA during the 1990s will be difficult to repeat elsewhere, although some low-performing countries may be able to move up the ladder of R&D/value added by becoming more R&D intensive. On a more optimistic note, even though high growth cannot be assumed, there is no reason why it cannot occur if sufficient efforts are made, for example, to clear regulatory hurdles in the biotech sector and encourage the development of lead markets in nanotechnology application areas. World markets for the products of the IT sector are also likely to grow significantly, especially in China, Russia and India. The onus is thus on industry and governments alike to seek out and exploit all possible opportunities for growth in the many different settings that exist both within and beyond the EU.

2.1.5 The Human Resource Gap

Since most R&D expenditure is composed of staff salaries, the ability of the EU to close the R&D gap will also depend ultimately on the availability of research personnel to perform the additional expected R&D. Unfortunately, as Soete (2002) has pointed out, the EU is currently at a disadvantage in this respect. In Japan, for example, where the current R&D intensity is already 2.9% of GDP, the number of researchers (FTE) per thousand of the workforce is 9.3. In the EU it is 5.3, a figure that will have to rise by 70-80% if the 3% of GDP target is to be attained. Moreover, Exhibit 2.13 shows not only that the percentage of scientists and engineers in the private sector of the labour force is considerably higher in the US and Japan than it is in the EU, but also that growth rates have been lagging in the EU over the last decade or so. Rectifying this situation will thus be an uphill struggle requiring significant improvements to the flow of scientists and engineers through the educational pipeline.

Exhibit 2.13 Science and Engineering Researchers as a Percentage of the Labour Force



1998

(Average Annual Growth Rates for 1990-1998 in Parentheses)

Source: Soete (2002)

It should also be noted that attaining the necessary levels of scientists and engineers is complicated by demographic factors: the EU S&T workforce is ageing and the pipeline of new science and engineering graduates is not strong. There are fewer students entering university and a declining share of enrolments in science and engineering. Meeting the 3% target will require increased domestic (i.e. EU) production of scientists and engineers and recruitment from abroad, which means diverting existing flows to the USA and tapping new sources.

2.1.6 Policy Implications

The policy implications of the figures presented so far are as follows:

- The size of the gap, its roots in business-oriented R&D and the relationship between business-oriented R&D intensity and productivity growth all suggest that the gap is a legitimate source of concern for policymakers within the EU;
- The gap, however, is not the only source of concern. Increasing the efficiency and effectiveness of R&D and innovative activity is arguably even more important, and policies tackling this issue should be reinforced rather than replaced by a focus on closing the gap;
- The fact that a substantial proportion of the gap can be attributed to industrial structure differences suggests that policy responses to the gap go beyond the sphere of R&D or innovation policy and into the realm of macroeconomic and industrial policy;
- Similarly, political attempts to promote market expansion and policy coordination across the EU will be needed to offset some of the scale advantages currently possessed by the US;
- National variations in business-oriented R&D intensity across the EU and the accession countries suggest that efforts to raise R&D intensity levels across the board should be complemented by targeted efforts to raise levels significantly in the cohesion and accession countries and in less favoured regions (LFRs) within some of the larger economies (provided, of course, that these efforts are complemented by parallel efforts to nurture other innovation-related capacities and competence levels);
- Even though strenuous efforts will be needed to raise R&D intensity in LFRs and the cohesion and accession countries, where the gap is most pronounced, the fact that most R&D is performed in the larger economies (Germany, France and the UK account for two thirds of GERD in the EU) means that efforts to raise R&D intensity in these countries are even more critical if the 3% target is to be reached;
- Sectoral analyses reveal that the EU lags the US primarily in the IT and Services sectors, the latter of which includes the Software sector, with the implication that policy efforts to close the gap would require special attention to these sectors;
- Efforts also have to focus on the establishment of vanguard positions in the newly emerging markets associated with biotechnology, new materials and nanotechnology;
- The size of the gap and the growth rates in business R&D expenditure that are needed to close the gap by 2010 argue for the urgent formulation and timely implementation of appropriate policies across the EU;
- The nature of the gap calls for a shift from national economies populated by SME-dominated, low and medium-tech sectors to those with a larger proportion of high-tech firms and large research intensive conglomerates
- Without parallel actions to improve the supply of qualified scientists and engineers in the EU, other policy initiatives to close the gap are likely to be in vain.

2.2 Understanding Private Sector R&D Investment Behaviour

Policies designed to bridge the business R&D gap need to be based on an understanding of:

- The different routes which can be taken to close the gap;
- The motivations which underpin R&D investment decisions in different types of firms and contexts;
- The R&D investment barriers that exist in different situations.

In terms of routes capable of closing the gap, business sector R&D in the EU can be increased, *inter alia*[2], via:

- Firms with R&D capacity outside the EU (e.g. large Multi-National Companies (MNCs)) relocating it within the EU;
- Firms with existing R&D capacity increasing their expenditure on R&D;
- Firms with no R&D capacity or experience initiating R&D activities or outsourcing;
- The creation and growth of new R&D performing, high tech start-ups;
- Combinations of all these routes.

The motivations and barriers that shape investment decisions differ for each of these routes, as do the policies needed to stimulate additional R&D expenditure in the EU.

2.2.1 Relocating R&D

Over the last decade or so, the dictates of globalisation have led many EU-owned firms with multi-national operations to locate R&D facilities in the US and elsewhere. There have also been flows into the EU, but net flows have been outward. Given the size of the firms involved and the associated levels of R&D expenditure, reversing this trend would have an appreciable impact on business R&D levels in the EU. It would also constitute an important ingredient of any attempt to reconfigure the industrial structure of the EU. However, the investment decisions of multi-nationals concerning the location of R&D facilities are driven by many factors, the most important of which tend to be proximity to key markets, the availability of skilled researchers and convenient access to knowledge infrastructures. Effective policies to stimulate relocation would necessarily have to target these framework conditions, many of which are the concern of broad economic or educational policy and lie outside or at the margins of conventional large-firm-oriented R&D policy. More subsidies for large firms to perform R&D are not the answer. A better approach to attract large firm investments is to nurture the growth of lead markets, improve market access and regulatory frameworks, strengthen the public research base (universities and public labs), stimulate the creation of NTBFs and strengthen the R&D capabilities of the larger population of SMEs, so that large firms find them attractive suppliers (i.e. a strategy of feeding the fishes rather than the whales).

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[2] Less obvious ways of raising R&D expenditure levels involve raising salary levels for researchers and redefining R&D expenditure to include 'soft' research on business management and organisational innovation. Both these routes might appear trivial at first sight, but neither should be dismissed out of hand because of the catalytic effects they could have on career attractiveness and the stimulation of best practice within firms.

2.2.2 Increasing R&D

Firms with existing R&D capacity tend to increase expenditure on R&D only when there is a perceived need and when adequate resources are available to overcome any barriers to fulfilling this need. Appropriate policies to stimulate R&D expenditure thus often fall into three broad categories: those which create opportunities; those which help firms to recognise new opportunities and translate them into perceived needs; and those which help firms – small and large – to overcome any obstacles that stand in their way. Again many of these policies are those that deal with framework conditions such as the education and training of researchers and the resolution of human resource constraints, but others fall more directly under the heading of R&D policy. Procurement policies that call for technological solutions requiring R&D, for example, can create new, demanding markets, and public investment in basic research can create new technological opportunities for firms to exploit. In terms of recognising new opportunities, foresight exercises can stimulate interest in new research areas, and awareness campaigns can also reorient research priorities. More directly, grants and loans for R&D projects help firms not only to recognise new opportunities, but also to overcome financing barriers. More indirectly, R&D taxation incentives can accomplish the same job. Collaborative R&D programmes and similar measures also locate firms within a broader knowledge infrastructure and help overcome barriers related to restricted knowledge flows.

Policies to stimulate demand for the products of technological innovation and promote their diffusion constitute another category that can affect R&D levels. Enhanced market prospects affect perceived risk-reward ratios, lower entry barriers and make R&D more attractive, while resultant sales generate profits that can be ploughed back into R&D. Similarly, many measures designed to improve the commercialisation of R&D results and enhance the innovation performance of firms also have a subsequent, indirect but nevertheless positive impact on R&D levels. Although they may be more difficult to assess, innovation measures that have indirect impacts may be as, or even more, important than other R&D support measures.

2.2.3 R&D Novices

Perhaps the most difficult area to address in terms of increasing R&D expenditure in the EU concerns the initiation of 'R&D virgins' into the circle of R&D performing firms, or at least into the circle of firms willing and able to benefit from R&D performed by a service provider, e.g. a contract research organisation. Non-R&D performing companies constitute the vast majority of firms in the EU, many of which are SMEs active in the more traditional, low-tech sectors. Typical innovation-related deficits for firms of this type comprise non-existent or weakly developed in-house R&D competence, low levels of R&D and innovation expenditure as a percentage of turnover, very limited co-operation with public research institutions and/or other companies, and a negligible share of world markets for high-tech products. The motivation to perform R&D is often absent because of a lack of perceived need, even though it is becoming increasingly obvious that SMEs of this nature are likely to struggle in a knowledge-driven economy unless R&D and innovation policies with a broader reach and a focus on raising awareness and competence building are implemented by governments across the EU. Efforts also have to be made to introduce these SMEs to contract research organisations and to support their interaction.

2.2.4 Start-ups

Innovation policies aimed at the creation of new, high-tech R&D performing firms have a direct impact on R&D levels in that they give birth to new R&D actors. Such impacts are typically small in the short term, but potential long-term impacts are much greater if high-tech start-ups and spin-offs thrive and prosper, for they are generally recognised as important sources of innovation. One only has to look at US start-ups in recent decades (Microsoft, Cisco, Sun, Microsystems, Genentech etc.) to see how successful start-ups can drastically alter the industrial landscape in relatively short periods of time. Such firms are important ingredients of efforts designed to nurture new technological areas and stimulate industrial growth, not only because of their own highly innovative and research intensive behaviour, but also because they catalyse similar behaviour amongst their competitors, suppliers and customers.

2.2.5 SME Barriers

Access to external capital is critical for new start-ups and spin-offs. In a similar vein, access to capital for R&D activities is also a barrier that particularly affects SMEs generally and NTBFs in particular. Larger firms tend to finance the bulk of their research out of profits[3] and public policies only tend to stimulate activities at the margin (though many of these marginal activities involve collaboration with universities and SMEs, where spillover and network effects are highest). For smaller firms, however, access to external capital is often a decisive factor in R&D investment decisions and public policies that affect the availability of external capital can play a critical role in determining overall R&D funding levels within existing SMEs.

Although financial constraints are particularly important for R&D investment by SMEs, other constraints also play a role. The shortage of skilled R&D personnel is a direct constraint on R&D activity often reported by high-tech and innovating SMEs. Other constraints typical for SMEs may be considered indirect constraints on R&D investments, insofar as they impact on the cash flow generated by the firm. The lack of experienced managers, such as finance and marketing managers, needed to complement the technical skills typically held by the firm founder, is a widespread constraint. A variety of market problems, such as lack of, or slow growth of, relevant markets, or an excess of competitors in these markets, can impact cash flow and thus R&D investment. Problems with technology transfer, or a lack of firms with the relevant experience needed to cooperate on an R&D project, represent bottlenecks hindering R&D investment. Finally, the lack of entrepreneurial talent willing to start up new firms is a problem in many European countries and regions, leading to a lack of entrants in new fields. A wide variety of public measures have been introduced to try to deal with these constraints, but with varying success.

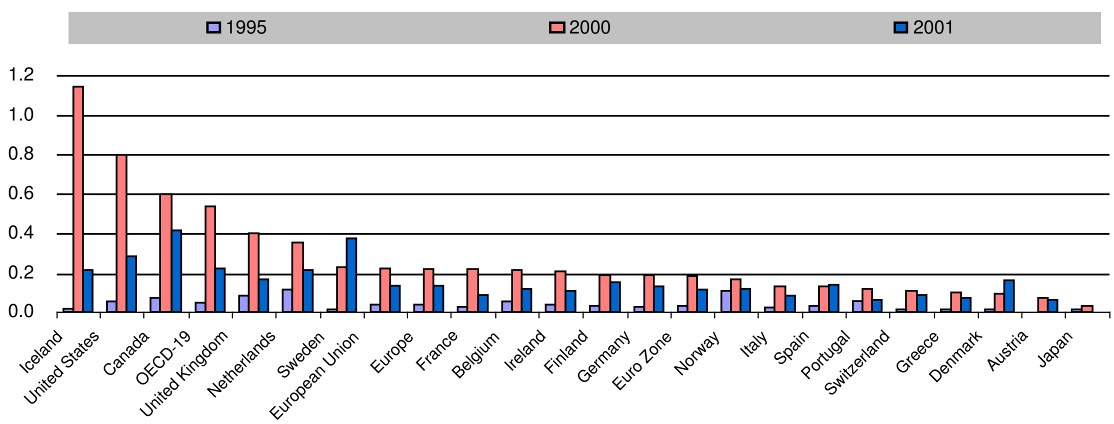
[3] That said, even large firms benefit from access to external sources of capital when profits margins are small or decreasing due to slow economic growth, stock market slumps, market saturation etc. The strong growth in volume of EIB loans to large firms in recent years is testimony to this.

2.2.6 Capital Gaps

Public policies to improve access to external capital would not be needed if this access were sufficient. All the evidence, however, points to the existence of relative gaps in the supply of capital for R&D, innovation and start-ups within the EU. Venture capital levels in the US, for example, are considerably higher in the US than in the EU (Exhibits 2.14 and 2.15), though there has been some contraction in the wake of the dot.com shakeout. In 2000, the United States had USD 106 billion (€93.4 billion) invested in 5,380 companies, of which about USD 80 billion (€70 billion), or approximately 0.8% of GDP, was early- and expansion-stage funding.[4] Canada, the Netherlands and the United Kingdom also had levels of early- and expansion-stage venture capital above 0.3% of GDP in 2000, while the EU average only reached 0.22%.

Exhibit 2.14 Growth of Venture Capital Markets in OECD Countries 1995-2001

Early- and Expansion-stage Financing as a Percentage of GDP

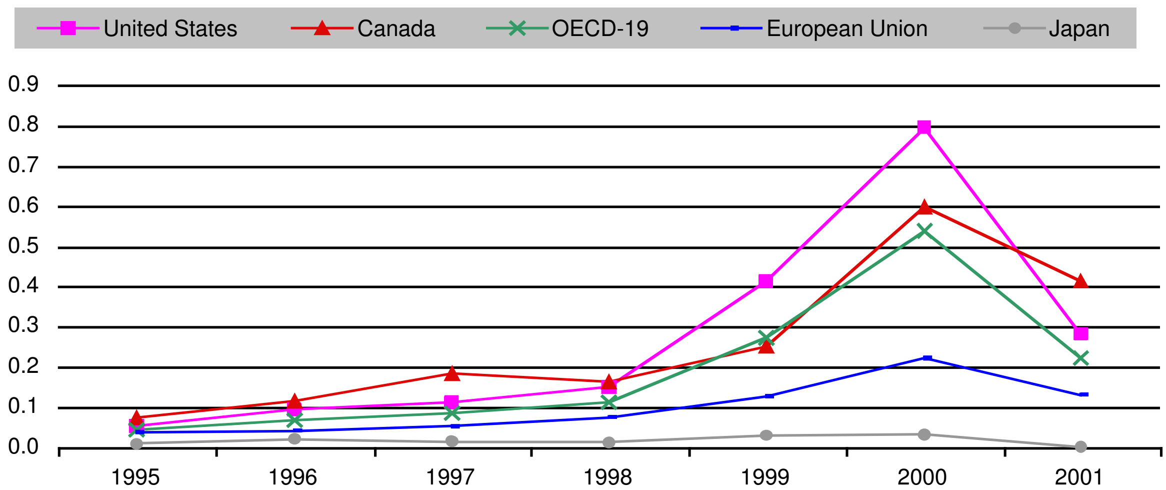


Source*: OECD*

4 Data from the National Venture Capital Association. See www.nvca.com

Exhibit 2.15 Trends in Venture Capital Funding in Major OECD Countries and Regions

Early and Expansion Stage Venture Capital as a Share of GDP



Source*: OECD*

Venture capital supports R&D indirectly by providing financing to risky business ventures. Early- and expansion-stage venture capital, in particular, tends to finance the activities of small, growing companies that are active in high-technology fields. Because these firms also tend to be highly R&D-intensive, early- and expansion-stage venture capital is thus a critical source of finance for R&D in small companies (Hyytinen and Pajarinen, 2002). In the United States, for example, increased venture capital funding appears to have helped spur increases in the share of business R&D conducted by SMEs. R&D expenditures of SMEs increased at almost twice the rate of those of large firms between 1990 and 2000, with R&D expenditures of the smallest firms increasing most quickly (Exhibit 2.16). As a result, their share of total industry R&D expenditures grew from 12% to almost 20% between 1990 and 1999 before declining to 18% in 2000 (OECD, 2002a).

Exhibit 2.16 R&D Expenditures by US SMEs 1997-2000

Millions of Constant 1995 USD

No. of Employees	1997	1998	1999	2000	% Change 1997-2000
Fewer than 25	2,730	4,088	5,986	5,435	99%
25 to 49	2,642	2,713	4,103	4,379	66%
50 to 99	3,676	5,540	6,201	6,171	68%
100 to 249	6,358	7,117	6,124	7,640	20%
250 to 499	5,628	5,934	6,935	6,239	11%
Total SME	21,034	25,393	29,349	29,846	42%
SME share	16.4%	18.4%	19.6%	18.1%	

Note: SMEs defined here to have <500 employees

Source: OECD (2002a); based on data from National Science Foundation, 2002

Rectifying venture capital gaps will not be easy in the current climate, however. The economic downturn that began in 2001 resulted in a significant decrease in venture capital funding and its redirection towards expansion funding for established companies (Richtel, 2001). US venture capital funding declined steeply in 2001, from USD 106 billion (€93.4 billion) in 2000 to USD 41 billion (€36.1 billion) in 2001, of which USD 30 billion (€26.4 billion), or 0.3% of GDP, was for early and expansion stages. European venture capital also declined significantly between 2000 and 2001, from a high of €19.6 billion to €12.2 billion, with early and expansion stage funding in the EU declining to 0.13% of GDP. In contrast, Sweden and Denmark saw steady gains in venture capital as a share of GDP.

Remedying the availability of capital for research-related activities also calls for a keen understanding of the way different capital markets operate and the reasons why some under-perform in the EU. There are distinct differences, for example, between the markets for pre-seed capital (e.g. capital used to nurture the transformation of research endeavours into business start-up proposals), early-stage capital (e.g. venture capital provided in exchange for equity at the seed and start-up phases), and expansion capital (sometimes provided via hybrid debt and equity finance packages). Problems arise with the latter, for example, because of the scarcity in the EU of specialised lenders with an appetite for providing loans to SMEs where expected returns (including those associated with the equity part of the package) are substantially above normal bank margins but significantly below those expected with normal venture equity. Public policies affecting the operation of these markets thus need to be finely tuned if they are to be effective.

2.2.7 Systemic Behaviour

The scale of the structural changes needed to transform the EU into a research intensive, high-tech, knowledge-based economy make it highly unlikely that any single route – in isolation – will be enough. Large MNCs will need to increase the share of their R&D capacity in Europe; existing R&D performers will need to increase their expenditure on R&D; low-tech firms will need to upgrade and initiate R&D activities; and efforts will be needed to encourage new high-tech start-ups and spin-offs. **This perception is**

reinforced by the simple observation that innovation within a knowledge-based society is a complex process in which the fates and fortunes of multiple stakeholders are inextricably linked. Large firms bond in strategic alliances; SMEs form integral parts of the supply chains of larger firms; firms of all shapes and sizes interact with universities and other research institutions in the quest for knowledge and technological advance. Innovation takes place in wide networks or 'innovation systems' in which academics and companies from the same and different sectors benefit from – and depend upon – the sharing of complementary competences. **In such complex, inter-related environments, policies designed to influence the actions of any one set of actors invariably have consequences for others**. More to the point, however, such 'single actor' policies may just constitute noise in the system unless they are reinforced by measures acting on other innovation system members which complement and reinforce each other.

Efforts to influence R&D investment behaviour in complex and turbulent environments thus need to be based not just on an understanding of the factors which influence the R&D investment behaviour of individual firms, but also on an understanding of what influences their collective behaviour, i.e. the systemic behaviour of the innovation systems to which different firms and other innovation-oriented actors belong.

2.2.8 Policy Implications

Consideration of private sector R&D investment behaviour has the following policy implications:

- Appropriate policies are path or route dependent, i.e. they depend on context and history;
- Policies aimed at persuading global companies to locate or relocate R&D facilities in the EU have to target framework conditions and are likely to involve a mix of policies, many of them lying outside the conventional sphere of R&D or innovation policy;
- Policies which strengthen the public research base and the technological base of potential suppliers are attractive to MNCs when locating R&D capacity;
- Stimulating additional R&D expenditure in existing locations requires policies that create opportunities, policies that help firms to appreciate needs and opportunities, and policies that help them overcome any obstacles in their path;
- Policies to stimulate demand and improve the innovation performance of firms have a pull-through effect which makes it more attractive to undertake R&D;
- Many of these policies again lie outside the realm of R&D and innovation policy, though many lie directly within it;
- Given the potential vulnerability of many EU SMEs within the context of a knowledge-driven economy, there is a need for policies with a broad reach that aim not only to upgrade the activities of existing R&D performers, but also to introduce newcomers to the fold;
- Policies encouraging start-ups and spin-offs have small immediate impacts but important long-term consequences for R&D levels;
- Access to capital is a major problem within the EU which can be and should be addressed by public policies;

- To be effective, public policies addressing capital deficiencies have to be finely tuned and based on a keen appreciation of the way capital markets work;
- Structural change will require complementary policies targeted at a variety of actors and based on an understanding of the dynamics of the innovation systems to which they belong.

2.3 In Search of Appropriate Policy Mixes

Policies to stimulate R&D investment levels in the EU should ideally be based on an understanding of the dimensions and causes of the problem. This section reviews the rationale for policies and explores the range of policy solutions on offer.

2.3.1 The Rationale for Government Intervention

The dimensions of the R&D gap have caused understandable concern in EU policy circles, and consideration of private sector investment behaviour does suggest that that there is scope for public policies to address the problem, but it is still pertinent to question the legitimacy of public intervention in this sphere.

The general argument for government support of basic research is long established. Nelson (1959) and Arrow (1962) explicated the public good aspect of basic research, emphasising that it is freely available through the channels of scientific publication. Its indivisible and non-excludable character causes companies systematically to under-invest, particularly in view of the uncertainty of selecting research with a commercially successful outcome. Since such research is socially beneficial there is a strong argument for government to fund this investment. This market failure argument has been further sophisticated by consideration of the different types of spillovers that occur. These encompass the appropriability of knowledge (for example through imitation), the benefits to users of the innovation not captured in its price, and network spillovers (when successful innovation relies upon developments in related technologies (Jaffe, 1996).

These arguments are used to underpin the policy rationale both for state support for public sector science and for financial support for early stages of industrial R&D. In the latter case, the argument is that research, particularly when it is further from the market (or 'pre-competitive') merits investment, but that development activities should be left to the market. A strict interpretation of neoclassical economics allows for financial support for R&D but warns against 'government failure' whereby policies may distort the market with more damage than the market failure which they seek to rectify, for example by crowding out competitors' R&D or by consuming scarce research labour resources. This leaves adherents of this interpretation most comfortable with fiscal measures because of their non-discriminatory nature, which avoids the problem of government officials 'picking winners' either in technologies or in companies. They do not, however, circumvent the problem of input additionality, that is to say, whether companies are given financial support for research that they would have undertaken anyway ('deadweight').

More recent conceptual and empirical developments have exposed the limitations of a perspective based solely upon market failure. The empirical observation is that industrial innovation does not conveniently segment itself into the stages of the linear model, whereby applied research follows basic, and is itself followed by development and commercialisation, with all of the outputs of each stage being consumed by the following one. It is now generally recognised that innovation is an interactive process with numerous feedback loops and reverse flows of causation. Universities and firms no longer have totally distinct roles (Gibbons *et al*□, 1994) and compressed timescales for industrial R&D further conflate the stages of innovation (Coombs and Georghiou, 2002). This challenges the construction of state support measures based on definitions of knowledge producing and exploiting activities that are increasingly questionable.

It has also become clear that a rationale applicable to large firms with the ability to mobilise substantial capital resources and to exploit existing capabilities and market networks may not apply to small innovating firms, notably to start-ups. Here the uncertainty extends beyond the technology and encompasses the firm's managerial capability to innovate. The market solution to this has been the growth of venture capital activity, but here too there are failures. A frequent problem is that promising concepts are unable to attract sufficient investment to reach the stage where a business case can be made to a commercial investor. Highly promising ideas may fall by the wayside at this stage. This has led to a number of public interventions in the early, seed or pre-seed stages, with the rationale that the state may have access to better scientific advice, perhaps following on from earlier support of the R&D stage of the work, or may be able to be more patient with its investment, allowing more time for uncertainties to be resolved or for the idea to gestate. Furthermore, market failure presumes the existence of a market. State action may be justified in terms of demonstrating the benefits to commercial investors to the point where the state may exit the market.

More recent thinking, emerging from a neo-Schumpeterian perspective, emphasises the possibility of system failures. These emerge from the systems of innovation perspective and emphasise coordination problems at a system level. Smith has articulated the concept (Smith, 2000) through four types of manifestation, failure in infrastructure provision, failure to achieve transitions to new technological regimes, failure from lock-in to existing technological paradigms, and institutional failure (regulation, standards and policy culture). These are concerned with the absence of bridging institutions to facilitate knowledge flows. Many direct measures are now focused on this rationale, embracing for example the need to improve the flows of knowledge between public science and industry. Often the aim of the policy is to improve the capabilities of organisations to be involved in innovative activities (for example training and advisory schemes) or to become aware of opportunities to innovate (for example foresight programmes). Specific measures may have multiple features. For example R&D subsidies may be linked to requirements to collaborate nationally or internationally to promote the creation of new or reinforced innovative networks. By contrast with the simple input additionality test of whether the firm is spending incrementally more on R&D (or on a specific R&D project), an evaluator under this rationale would look for persistent behavioural changes which evidence a lasting change in innovative capability and, *inter alia*, a higher platform level of R&D investment (Georghiou, 2002).

It should also be noted that the state might have motives for support for industrial R&D which link directly to its own activities. In particular the state may support industrial R&D to ensure that its own procurement requirements are met in areas such as health and defence. The existence of the state as a monopsonistic customer combines with an often complex and specialised set of requirements that the market cannot deliver. Even in areas where the market does function, the state may wish to support R&D that informs its procurement decisions from that market. Similarly it may support R&D that informs its regulatory and legislative functions.

To summarise, our current understanding of the ways in which innovation systems work provides coherent arguments for the legitimacy of a broad swathe of policies addressing a range of market, information, capability, infrastructure, institutional and system failures.

2.3.2 The Range of Potential Policy Instruments

The range of policy instruments that affect R&D activities is vast and policy design is complicated by their number, diversity and potential to interact both positively and negatively. Instruments range from highly targeted mechanisms that provide direct financial support to individual organisations to perform R&D, to broad changes in the legislative and regulatory environments of firms which can and do affect a multitude of business activities, including those related to R&D. Lying in between these R&D specific mechanisms and broader measures that affect the general business milieu are instruments that differ along many other dimensions. Some measures involve the direct transfer of funds from the public purse to private organisations, while measures such as R&D tax incentives are more indirect in that they involve the state forsaking income rather than increasing direct expenditure on R&D. Other measures are aimed at innovation-related activities other than R&D, though many seek to enhance the commercialisation of R&D via improved links between R&D performing units and productive units, e.g. between universities and industry.

There have been many attempts to categorise and classify the policy instruments that affect R&D and innovation-related activities. The Trend Chart constructed and operated by DG Enterprise of the European Commission classifies instruments into 18 different types (including one 'Other' category), themselves clustered under three different headings that correspond to objectives and action lines within the European Innovation Action Plan, namely:

- Gearing research more closely to innovation;
- Promoting a genuine innovation culture;
- Establishing a favourable legal, regulatory and financial environment.

The majority of countries rely heavily on a small group of instruments, most of which are related to the objective entitled 'Gearing research more closely to innovation'. Instruments labelled 'Financing' instruments are also widely exploited. Instruments falling under the heading of 'Promoting a genuine innovation culture' are commonplace too, though less so in many of the accession countries. Instruments falling under the heading of 'Establishing a favourable legal, regulatory and financial environment' are used more sporadically in all countries, especially the accession countries.

For our purposes, since we are particularly concerned with the role of financial and fiscal instruments relative to each other and to other R&D and innovation-related policy instruments, the simple scheme depicted in Exhibits 2.17 and 2.18 is useful. In the first instance, three dimensions are used to differentiate R&D and innovation policies and their areas of application. The first dimension in Exhibit 2.17 distinguishes between the three types of financial and fiscal instruments identified in Section 1.0 of this report – Direct, Indirect Fiscal and Catalytic – and adds another – Other Direct Measures – which includes support for R&D and innovation performers other than the provision of finance for projects, e.g. access to advice, brokerage schemes, funding for networks etc. The second dimension distinguishes between policy instruments designed to support either R&D or innovation activities, with an intermediary category for instruments which support a mix of both activities; and the third dimension specifies whether an instrument is aimed primarily at private sector actors (e.g. firms), public sector actors (e.g. universities), or a mixture of both. Furthermore, in Exhibit 2.18, the R&D and innovation policy domain is located within the broader context of just some of the other policy domains and framework conditions which interact with and affect R&D and innovation policies and activities.

The shaded areas in the Exhibits correspond to those areas that constitute the focus of attention in this report (i.e. those which are most relevant to the topic of raising R&D investment levels in the private sector), with intensity of shading depicting the sharpness of focus. Within the sphere of Direct Measures, the area most under the spotlight is the direct transfer of money from the public sector to private sector R&D performers for the purpose of undertaking R&D projects. But other types of direct measure are also important. Just considering the top 'layer' in Exhibit 2.17, there are many other 'cells' of relevance to the raising of R&D investment levels in the private sector, particularly those in which finance is provided for projects which involve mixes of R&D and innovation and public and private sector RD performers. Many collaborative R&D programmes, for example, fall into these cells. The provision of finance direct to public sector actors for R&D and mixed R&D and innovation activities also has an indirect effect on R&D levels in the private sector because of the close links between a leading-edge public research base and its ability to attract and nurture a dynamic and innovative industrial base. In the remainder of this upper 'layer', support for innovation-oriented activities, such as grants for technology diffusion and absorption projects, are also of modest interest in that they help improve innovation performance and feedback both ideas for further research and, in the longer term, help generate profits which can be reinvested in R&D.

Many of the cells in the second 'layer' corresponding to 'Other Direct Measures' are also important. These typically include measures that provide services to R&D and innovation performers, e.g. access to information services, or even finance for purposes other than projects, e.g. infrastructural support. Even when these are provided to public sector actors, the strong links between the health and dynamism of the public and private research bases ensure their relevance to the quality and quantity of R&D performed by industry.

In the layer corresponding to Catalytic Financial Measures, the two mechanisms of most interest – Risk Capital Measures and Loan and Equity Guarantee Measures – have historically been used to stimulate the provision of external finance for innovation and other business activities within the private sector rather than to raise R&D levels. In this report, however, we are specifically interested in how these instruments can be extended to cover activities in the 'Mixed R&D and Innovation' cell. In contrast, Indirect Fiscal Measures have been used for many years to provide incentives for increased R&D expenditure in the private sector and the focus in this report remains firmly on this cell.

Exhibit 2.17 R&D and Innovation Policy Measures Affecting Public and Private Sector Actors

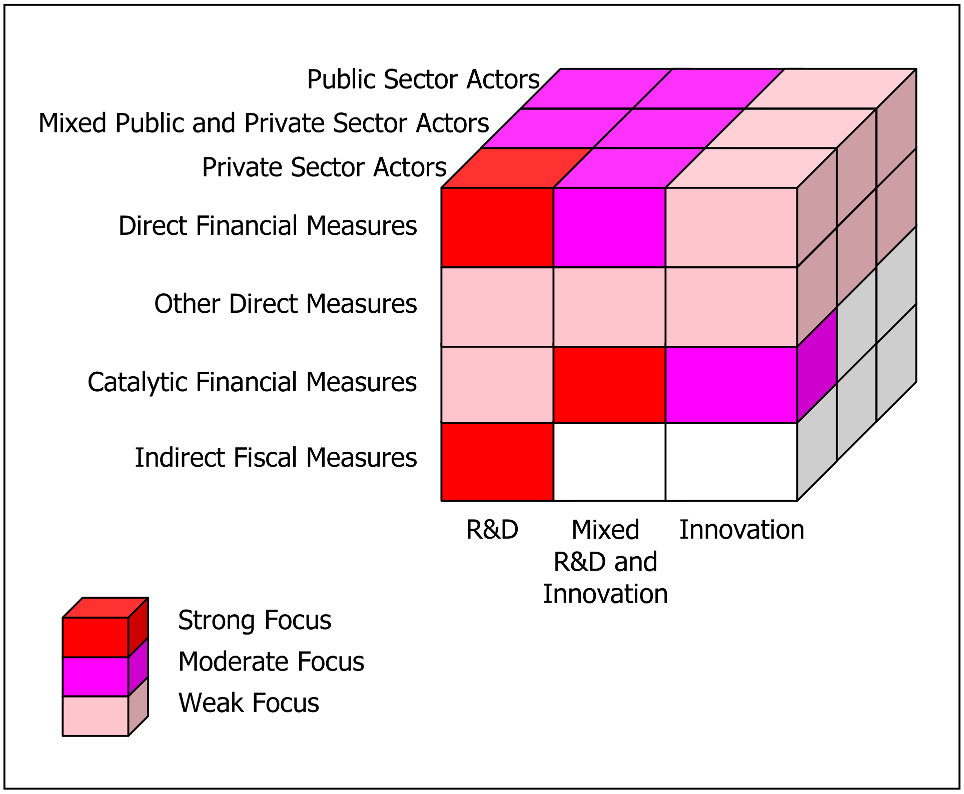


Exhibit 2.18 Framework Conditions and Policies Affecting R&D and Innovation Activities and Policies

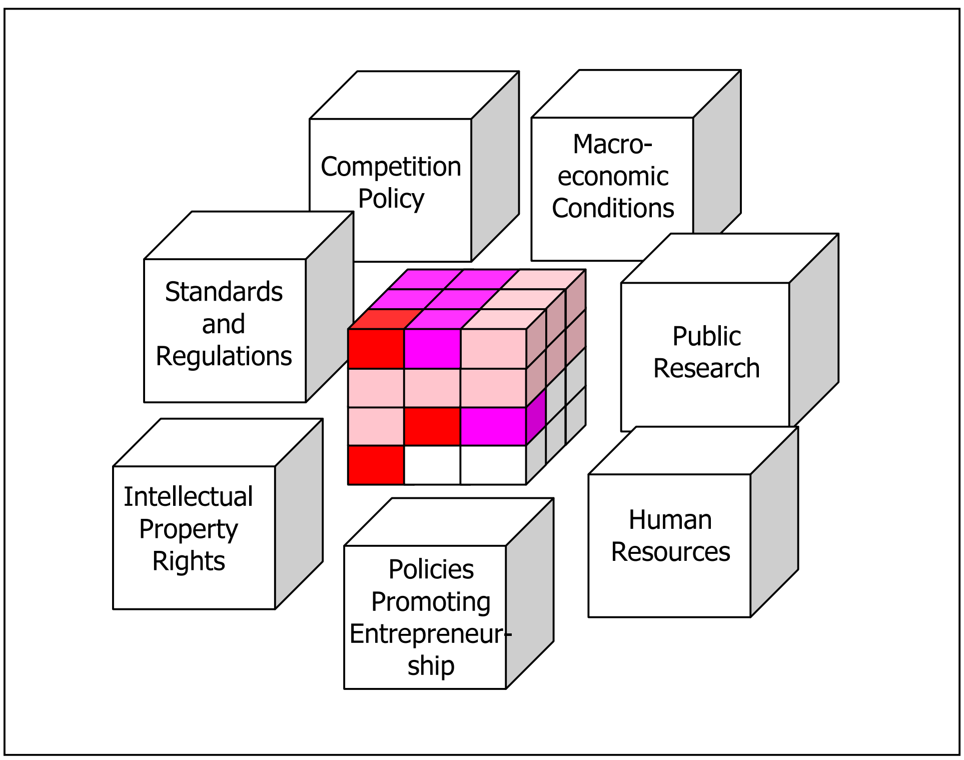


Exhibit 2.18 reminds us that policies in many other spheres affect the general framework conditions in which all organisations operate and which can influence a host of activities other than R&D and innovation. Their particular influence on the latter activities, however, is another keen focus of this report. Human Resource Policy, for example, not only affects general levels of education in the populace (which become increasingly important within the context of knowledge-based societies and the Lisbon targets), but also has a critical bearing on the numbers of students attracted to science and engineering as a career and on the flow of science and technology graduates into research. Similarly, Competition Policy affects a multitude of business-related activities, but in the R&D sphere it is particularly relevant to the framing of State Aid regulations for the public sector support of private sector R&D activities. Exhibit 2.18 is by no means exhaustive in terms of the areas it lists which can affect R&D investment levels, but it does contain those areas upon which this report focuses.

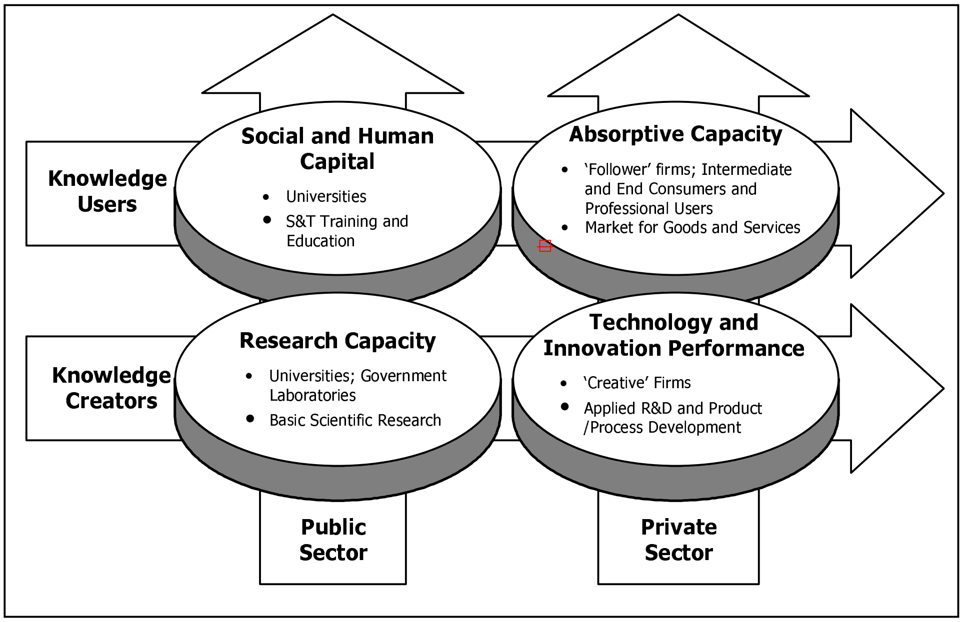
2.3.3 Highlighting Problem Areas

Although Exhibits 2.17 and 2.18 an be used to differentiate between different types of instrument and illustrates vividly the range of instruments with a potential impact on R&D and innovation activities, it provides no clues concerning the choice of appropriate instruments or policy mixes. This requires an examination of the problems these mechanisms are expected to address and scrutiny of fit for purpose.

Some of the problems concerning science, technology and innovation that are currently confronting many countries can be illustrated via simple innovation system models. Exhibit 2.19 is a simple representation of an innovation system comprising four interdependent sectors. Each constituent sector consists of interacting groups of actors, defined in terms of their membership of the public and private sectors and their roles and activities as either 'knowledge creators' or 'knowledge users'. Each sector can also characterised by a dominant issue in contemporary discussions about innovation policy: namely the supply and demand for qualified human resources (Social and Human Capital); the strength and continual renewal of the underpinning knowledge base (Research Capacity); the ability of industry to innovate (Technology and Innovation Performance); and the capacity of markets to absorb and diffuse innovations (Absorptive Capacity).

A recent European Commission report on the benchmarking of the impact of R&D and R&D policies on competitiveness and employment (Soete *et al*, 2002) used this scheme to link and analyse data on a range of performance indicators for the four issues outlined above. Three of the issues were found to be highly correlated. The results suggested that countries in the EU could be divided roughly into three camps. The members of the first group (Sweden, Finland, Denmark, the UK and the Netherlands) all rank highly in terms of the highly correlated concepts of research capacity, social capability and technological and innovation performance. Conversely, the second group (Greece, Portugal, Spain and Italy) all have low rankings. The third group (Ireland, France, Belgium, Austria, Germany) have mid-spectrum rankings but less overt correlations between the three variables. France, for example, has a strong research capability but a low ranking for social capital and a moderate ranking for technological and innovation performance.

Exhibit 2.19 Indicative Issues, Actors and Activities in a Simple Science, Technology and Innovation System



Source: Based on Soete et al (2002) and Guy and Nauwelaers (2003)

The policy implication of this analysis is that efforts to close the gap between the highest and lowest performers cannot afford to focus on strengthening any one of these three performance parameters alone: all three have to be tackled simultaneously.

The results also indicated the absence of any correlation between any one of these three performance parameters and the scores for absorptive capacity – which were appreciably higher in the USA and Japan than they were in EU countries. In other words, irrespective of comparative strengths in other innovation system domains, the EU was, and is, demonstrably weaker in terms of its ability to absorb and exploit technology than either the USA or Japan – confirmation yet again of the existence of the oft-quoted 'European paradox'. The lack of a clear relationship suggests that a concerted focus on improving absorptive capacity will necessarily have to be additional to efforts to improve performance in terms of the other parameters.

2.3.4 Mapping Policies onto Problems

The simple innovation system model used above can also be used to map policy instruments onto problem areas. R&D and innovation policy practice in the EU is depicted in Exhibit 2.20. This uses the model to differentiate between those policies that strengthen and reinforce capabilities and activities within a sector (reinforcement policies), and those which attempt to initiate or strengthen the links between actors and activities in different sectors (bridging policies). The figure – which should not be considered an exhaustive list – uses real world examples drawn from an inventory of science, technology and innovation policy instruments in the EU.

Exhibit 2.20 Overview of R&D and Innovation Policies in the EU

Reinforcement Policies for Public Sector Knowledge Users • Public support to education institutions and programmes • Actions to raise awareness on S&T studies (many countries) and technical vocational courses (NL), or awareness of science in the larger public e.g. promotion at primary and secondary schools (SE) • Creation of Interdisciplinary Graduate Schools (DK), Graduate Schools system (FI, SE) • Modernisation of vocational schools (DE) and apprenticeship system (UK) • Increased funding for Polytechnics	**Bridging Initiatives between Public and Private Sector Knowledge Users** • Role of Polytechnics, Technical Lyceums to support companies (AU, FR, DE), Technocentres (NL) • Training in ICT (many countries) • Lifelong Learning initiatives (several countries) e.g. Open Universities for Adult Education (FI), retraining of labour force (NL), Adult Education Programmes (SE) • Promoting positions for graduates (several countries) e.g. FR, IT, PT, NL (KIM), UK (TCS) • Innovation and entrepreneurship courses at high schools (most countries) e.g. Science Enterprise Challenge (UK)	**Reinforcement Policies for Private Sector Knowledge Users** • Innovation-oriented Business Support structures (most countries) e.g. NL (Syntens), GR (KETA), LU (Luxinnovation), SE (ALMI) • Support for technological development in firms (most countries) • Support to counselling activities in firms (most countries) e.g. National Workplace Development Programme (FI) and support for training in firms (most countries) e.g. ES (CRECE) • SME specific financial programmes (most countries) e.g. BE (KMO-Innovatie programme), DK (Danish Growth Fund) • Entrepreneurship promotion programmes (many countries) e.g. FI (entrepreneurship training) • Incubators (most countries): space, finance and advice in the same place • Capital and Seed Investment (most countries) e.g. FI (Sitra)
Bridging Initiatives between Public Sector Knowledge Users and Knowledge Creators • Collaborative programmes between universities and high education establishments • IT infrastructures for science, industry and public e.g. DE	**Bridging Initiatives between Public and Private Sector Knowledge Users and Creators** • Cluster policy e.g. AU, BE, DK, FI, DE (Innonet), GR, NL • Regional growth centres: co-operative centres gathering technology services, training, firms, R&D (DK); Centres of Expertise (FI); Regional networking initiatives, InnoRegio, Innovative Regional Growth Poles (DE)	**Bridging Initiatives between Private Sector Knowledge Users and Creators** • Demonstration activities targeting companies e.g. AU (TechnoKontakte) • Mentoring schemes between large and small firms e.g. BE (PLATO) • Support for co-operative R&D projects linking developers and users of new knowledge
Reinforcement Policies for Public Sector Knowledge Creators • Public support to universities and public research labs (all EU) with focus on 'excellence' poles • Reform of public research organisations (e.g. DE, IT, GR, SE, UK) and of status or career of researcher (e.g. GR, NL, UK) • New university or research centre creation (ES, GR, LU) • Targeted business-oriented R&D programmes carried out by Public Research Institutions (many countries, e.g. IE (PAT)) • Support to Young Scientists (many countries e.g. UK (START), GR (YPER), DK) • Improvement of doctorate and post-doc research (several countries) e.g. ES, FI, GR (PENED), IT, PT • Support for integration of research by various PRI e.g. BE (inter-university attraction poles) • Support for internationalisation of research (most countries) • Attraction of foreign researchers: e.g. DE, GR (ENTER)	**Bridging Initiatives between Public and Private Sector Knowledge Creators** • Mobility programmes for researchers in industry (most countries) e.g. BE (FIRST), ES (Torres Quevedo), FR (CIFRE & CORTECHS), DK and SE (Industrial PhD programmes), PT • Spin-off promotion programmes (most countries) e.g. AU (A+B), FR (contest), DE (EXIST), GR (PRAXE) • Third Mission for universities (several countries) e.g. ES, SE • Support to R&D in PRIs with potential for commercial exploitation (most countries) and legal changes to promote spin-offs e.g. FR, ES • Liaison Offices at universities (most countries) • Science Parks and Technopoles (most countries) • Grants for collaborative research projects (most countries) or networks e.g. DK (large cross-disciplinary research groups), DE (Leitprojecte), UK (LINK) • Public-Private Competence Centres, e.g. AU (Kplus), and networks (DE, SE) • Technology diffusion centres and networks (most countries) e.g. BE (collective research centres), DK (GTS), ES (technological centres), FR (CRITT and RDT)	**Reinforcement Policies for Private Sector Knowledge Creators** • Support for R&D projects in companies: grants, loans, capital investment, guarantee mechanisms (most countries) e.g. ES (CDTI), FR (ANVAR), DE (ProInno), PT (Agencia de Innovaçao), UK (SMART) • Support for R&D programmes conducted by business consortia e.g. IT • Tax incentives for R&D in companies (AU, BE, ES, FR, IE, IT, NL, PT, UK) • Risk and Seed Capital Funds, Business Angel networks (most countries)

Source: Based on Soete et al (2002) and Guy and Nauwelaers (2003)

Consideration of Exhibit 2.20 prompts a number of observations. In the first instance, it is readily apparent that the same types of instrument are used in many member countries, albeit with slight differences in emphasis and orientation to suit local contexts, and that these comprise both reinforcement and bridging policies. This reflects a degree of copying and imitation, especially over the last decade or so.

A related point, not immediately discernible from the figure but certainly evident from a more detailed scrutiny of national R&D and innovation policies, is that many countries are now implementing a similar mix of policy instruments in terms of their number and function. The larger and more mature economies tend to have the greatest number and variety of instruments, but many of the smaller economies also use similar mixes – even if there is still a great deal of variation in terms of modes of implementation and relative effectiveness. Again, however, there is the suspicion that the use of similar combinations is a consequence of simple imitation rather than the result of deeply considered reflections on the appropriateness of particular policy mixes.

A third observation is that a growing number of programmes, actions and measures are located in the lower middle sector (Bridging initiatives between Public and Private Creators of Knowledge), highlighting a strong focus on policies fostering industry-science relationships. This reflects policy efforts to improve the connection between Europe's strengths in basic and applied research and the commercialisation of these discoveries, i.e. attempts to resolve the 'European Paradox'.

A fourth observation is that most of the innovation and diffusion-oriented elements of the policy mix can be found in the upper-right hand sector labelled 'Reinforcement Policies for Private Knowledge Users', an area which lies at the interface between technology policies and business development policies.

A fifth observation is that the central cell in the figure (initiatives bridging both public and private sectors and knowledge creators and users) contains a small number of programmes that can be tentatively described as systemic policies. These are all very recent initiatives that reflect contemporary efforts to go beyond the building of bridges between contiguous sets of actors in the figure. Critically, these instruments encourage wider sets of actors to interact with each other in ways which allow a variety of user needs to influence knowledge production and, conversely, knowledge production capabilities to shape user expectations and strategies. Examples include so-called 'cluster' and 'technology platform' policies, both of which involve 'policy packages' comprising a mix of support instruments and the participation of a diverse set of stakeholders. Because they often have a regional dimension, policies of this nature often call for the involvement of regional authorities and the coordination of activities between regional, national and EU levels.

A number of other trends in the formulation and implementation of European R&D and innovation policies complement the picture painted by Exhibit 2.20.[5] They all suggest that increasing attention has been paid in recent years to bridging policies and to policies concerned with the functioning of innovation systems as a whole. In summary:

- The number and diversity of measures in use in different countries increases with the size and maturity of the national innovation systems;

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[5] See, for example, the EU Benchmarking Report on 'The Impact of RTD on Competitiveness and Employment' (Soete *et al*, 2002), and Chapter 3 of the OECD STI Outlook 2002 (OECD, 2002a)

- The cohesion countries also now have a diverse and plentiful mix, but the accession countries generally exploit fewer measures;
- Higher education institutions have been expected to play a greater role in the innovation process;
- Other publicly-funded research institutes and organisations have been encouraged to direct their research efforts to areas of interest to the private sector;
- Direct subsidies to private sector firms have decreased substantially in many countries, though direct funding for business R&D remained above 0.2% of GDP in the USA and Sweden in 2001 and had increased in some of the smaller OECD economies (OECD, 2002a);
- Targeted support for specific technology areas has, to some extent, been replaced or at least supplemented by more indirect support measures (e.g. fiscal R&D tax measures) and attempts to improve general framework conditions;
- Many governments have attempted to catalyse the growth of a private venture capital market;
- Greater emphasis has been placed on measures to diffuse technology, though the relative emphasis on measures dealing with the issue of absorptive capacity has remained weak;
- Some governments (e.g. Finland) have experimented with 'policy packages' which link disparate policy instruments and allow target audiences to customise the support they receive in line with varying needs at different stages of the innovation process;
- There is a small but growing recognition in some policy quarters that a holistic perspective is needed to nurture a balanced policy mix and avoid the piecemeal, uncoordinated application of multiple instruments.

2.3.5 Lessons from Innovation Systems Theory

Just as models of innovation systems can be used to identify and characterise problem areas and track policy responses, innovation systems theory is also the source of a number of helpful insights into the choice of appropriate policy mixes. The first of these is based on our current understanding of the complexity of modern innovation systems, each of which is composed of many different types of actor interacting in numerous and diverse ways. In such systems, system performance is often determined or regulated by the weakest node (i.e. the weakest link in the chain). The implication for policy formulation, therefore, is that policy interventions should target the weakest links.

A second lesson, which also stems from the complexity of innovation systems, is that individual policy instruments applied in isolation are unlikely to have a dramatic impact on overall system performance. In theory this is exactly what could happen if policies are targeted accurately at extremely critical weak links, but in practice the 'strategic intelligence' required to identify critical nodes is woefully inadequate. In complex systems, too, there are likely to be many weak nodes, and even accurate targeting of an individual weak link is only likely to produce incremental improvements if policymakers neglect other weak links. A corollary of all of this is that successful attempts by public policymakers to improve the performance of complex innovation systems are more likely to consist of the application of a broad portfolio of policy instruments than the application of any one instrument in isolation.

Applying a successful broad mix, however, again requires high levels of 'strategic intelligence' about the existence of weak links. It also demands an appreciation of the efficacy and appropriateness of individual policy instruments in different settings. In turn, this emphasises the need for constant experimentation and evaluation in the use of single instruments and combinations of instruments, with the results of these assessments continually feeding back into policy formulation discussions.

An innovation system perspective also suggests that the constituent parts of the system have to perform well if the system is to function effectively, and that all parts need to interact smoothly too. There is no point in knowledge creation, for example, if the routes to knowledge use are blocked (which is precisely the reason why the funding of basic science will not lead to improvements in innovation systems if the weak nodes in the system correspond to the barriers between knowledge creation and use). Similarly, direct efforts to stimulate private sector R&D investment levels will have little overall impact if complementary measures to address weaknesses in absorptive capacity and human capital, for example, are not addressed in parallel.

2.4 Holistic and Focused Policy Solutions

The analyses contained within Sections 2.1 2.3 suggest the adoption of a nested approach to the construction of policy mixes capable of addressing and closing the gap in private sector R&D investment levels in the EU. At the highest level, there is a need for a holistic approach to policy formulation. 'Holistic Policies' involve the construction of policy portfolios of considerable breadth, aimed in the main at rectifying wholesale innovation system deficiencies that, if successful, would stimulate private sector investment in R&D as a natural consequence of a healthy and vibrant innovation system.

At the next level in a nested policy system, there is a need for the construction of more focused policy packages addressing specific problems within more limited innovation system domains. An example of a 'Focused Policy Solution' would be an integrated package of financial and fiscal measures addressing capital resource deficiencies amongst SMEs and start-ups.

2.4.1 Holistic Policy Solutions

There are three major weak spots in the EU innovation system that are particularly relevant to the task of raising private sector R&D levels:

- Large technology-based companies, MNCs in particular, are responsible for the bulk of R&D expenditure in the EU. As such, they are the largest potential source of additional R&D investment and would contribute most to closing the R&D gap – if only they could be motivated to allocate more R&D to locations within the EU. Rectifying the gap thus requires policies that make the EU an attractive place to conduct R&D;
- It is also evident that structural differences in the complexion of industry account for a substantial proportion of the gap between EU and US R&D investment levels – due largely to the relative size of the ICT sector in the USA. Rectifying this imbalance, whether by focused efforts to promote the growth of the European ICT sector or similar measures to promote other new lead markets and sectors in the EU (in pharmaceuticals, biotechnology, nanotechnology, new materials etc.), will require concerted policy efforts along a broad front;
- The relatively poor performance of the EU in terms of absorptive capacity signifies an inefficient innovation system. Measures to rectify this are needed if sufficient wealth is to be generated to raise future investment levels in R&D.

The scale and diversity of these problems have two major implications for policy. **Their scale suggests that there is a need for decisive steps to reappraise the efficacy of existing policies and to implement new, even drastic, measures to remedy deficiencies in the EU innovation system**. Incremental approaches that attempt to satisfy and appease all interested parties certainly have a part to play during the normal course of regional, national and EU policymaking, but when there is a need to shift gear and increase momentum, thinking the unthinkable becomes acceptable and the need for more drastic measures becomes an imperative. Secondly, **the diversity of these dilemmas calls for a similarly diverse set of policy instruments to tackle them**, with all the concomitant problems associated with mobilising these in a coherent way across a highly variegated set of policy levels (regional, national and EU) and an even more disparate set of institutional actors.

The need for diverse and drastic remedies was echoed in a recent survey (ERT, 2002) of the members of the European Round Table, which comprises many of the EU's largest R&D performers and accounts for more than 13% of total European R&D spending. The survey noted that the amount members expected to invest in the EU on R&D would be maintained or raised only slightly over the next few years, while investment levels outside of Europe were expected to increase. If EU GDP continues to rise, then private EU R&D expenditure as a percentage of GDP will fall and any hope of reaching the Barcelona target of 3% will recede dramatically. The ERT thus concluded that drastic measures were necessary to persuade its members to invest in R&D in Europe. A poll of members suggested that a broad policy mix comprising the following elements was required:

- Public investment in centres of R&D excellence in key areas such as ICT, advanced new materials and pharmaceuticals and the development of a broad range of measures to raise the status and improve the supply of skilled labour for R&D;
- Increased public spending on R&D to encourage more private R&D spending, including tax incentives and direct co-financing of R&D projects;
- Improved legislation covering Intellectual Property Rights and product regulations.

Moreover, the thrust of the ERT advice was that gradual or modest shifts or improvements in existing policies would not be enough, and that significant amounts of additional effort and money would be needed to make a significant difference to the current moribund state of affairs.

The mix of instruments required to tackle the above problems spans the spectrum of instruments we have termed Direct, Indirect Fiscal and Catalytic, plus numerous policy instruments affecting framework conditions, and the formulation and implementation of such a mix is certainly a challenge. The severity of the problems these policies are meant to surmount, however, demands that attempts are made to confront the challenge. Section 3 of this report thus focuses on some of the ingredients that could or should feed into appropriate policy recipes. In particular, the focus falls on some of the framework conditions and related policy measures that will need to be incorporated into Holistic Policy solutions.

2.4.2 Focused Policy Solutions

Whereas the Policy Mix Expert Group felt that considerations of industrial structure, absorptive capacity and the attractiveness of the EU as a place for large firms to conduct R&D were of primary importance in the construction of

Holistic Policy solutions, it also identified a need to raise R&D intensity amongst indigenous firms across a range of industrial sectors. Financial and fiscal policy mechanisms are well suited to this task, since they tackle many of the deficiencies that inhibit R&D activities, particularly amongst SMEs. These include scarce resources (often financial), insufficient incentives to take risks, missing capabilities and lack of opportunities (Metcalfe and Georghiou, 1998). In the short-term, such measures – when aimed at mid-sized companies, SMEs, new technology-based firms (NTBFs), start-ups and spin-offs – may only leverage modest amounts of R&D activity, but in the longer term the importance of new high-tech entrants and innovative SMEs to overall economic performance ensures the relevance and importance of policy efforts in this sphere. It should also be remembered that many financial and fiscal measures can also be exploited by large firms and MNCs, with important leverage effects on overall R&D investment levels. Section 4 of this report thus focuses on the role and use of specific financial and fiscal measures, while Section 5 looks at their use in conjunction with each other in Focused Policy packages and as part of broader Holistic Policy solutions.

3.0 Holistic Policy Solutions and Framework Conditions

At the heart of the argument concerning the desirability and necessity of holistic policy approaches is the realisation that business R&D investment levels are determined by many factors that lie outside the traditional sphere of either R&D or innovation policies. In this section, therefore, we review some of the broader policy spheres, framework conditions and related issues that need to be considered in the design of holistic policy solutions.

3.1 Macroeconomic Conditions

Macroeconomic conditions are in the long term the single most important factor influencing business expectations and investments. Innovation and business R&D investments are not an exception; they are indirectly but very strongly influenced by the macroeconomic climate. In difficult years, for example, such investments are very likely to be reduced because of the time horizons needed for their amortisation and the inherent uncertainty associated with R&D. The well-being of the macroeconomic environment – regulated by interest rates, open markets and fiscal measures – is thus a condition *sine qua non* for research to continue. Although R&D and innovation are drivers of economic prosperity, economic growth is also a prerequisite for the growth of R&D investment.

Macroeconomic and fiscal conditions are key framework conditions influencing investment in R&D for the following reasons:

- The general level of interest rates is an important determinant of the cost of capital. Low interest rates result in a lower debt service burden for indebted firms, thus freeing up cash flow for investment. Lower interest rates should also result in a lower thresholds for internal go-no go decisions on investments, which should induce a wider range of R&D projects to be financed;
- Price stability also supports R&D investment insofar as it increases the predictability of future costs and revenues and thus boosts the potential for profits should R&D projects be successful;
- A high growth rate in aggregate demand is also supportive of investment in R&D, since anticipation of future growth in markets is one of the main determinants of investment spending;
- In the long run, however, this growth rate should not exceed levels likely to lead to 'overheating' in Europe, since this can lead to the need for increasing interest rates and, in the worst case, 'stop – go' policies increasing the volatility and unpredictability of economic growth. There is evidence that growth rates in the US in the late 1990s were unsustainable, leading to overinvestment and overcapacity in ICT. This behaviour spilt over to a certain extent to Europe. The bubble in spending is now being corrected by a severe consolidation in high tech industries and drastically reduced IT spending by large corporations. Growth stability is particularly important for R&D, since much of R&D investment is in staff, most of whom cannot simply be made redundant or hired without efficiency losses. In an ideal situation, R&D spending should be smooth over the business cycle;
- The tax structure is one of the fiscal conditions influencing not only the level but also the location of R&D investment. Internationally mobile firms have the capacity to locate R&D activities where, among other things, tax considerations are favourable. Levels of fiscal generosity and the transparency and simplicity of tax systems all thus come into play. A further consideration is the stability of tax systems and the predictability

of tax authorities' treatment of firms, which can also influence the location and level of R&D.

Financial markets and labour markets are governed by general macroeconomic conditions and constitute framework conditions for innovation and, as a consequence, R&D.

Financial markets influence business R&D investments because they determine the cost of money. Most business activities are financed by own capital, the banking sector and/or access to the stock exchange. For big R&D intensive companies and global players, internal profitability and interest rates are critical elements in return on R&D investment calculations. General macroeconomic conditions are thus key determinants of R&D investment levels whenever large companies dominate business R&D expenditure in a country.

Intervention in financial markets can also influence R&D investments in other quarters by rectifying market failures and redistributing risk. Many companies outside the first circle of large R&D intensive companies are much more dependent on access to external sources of capital to fund R&D, and this access is not always easy to gain. This is especially true for low- and medium-tech SMEs wishing to invest in R&D and innovation, new technology-based firms (NTBFs) with little track record and start-ups and spin-offs.

Ideally, financial markets should:

- Provide equity finance (Venture Capital) to seed and early stage developments;
- Provide expansion capital for growing companies (mostly in the form of equity, but also debt and mixed equity and debt (mezzanine) finance to finance their marketing and distribution systems;
- Give access to debt finance to SMEs with a positive cash-flow without discriminating against them just because of their size and short track-record;
- Offer capital market instruments to more mature, but R&D-intensive companies.

However, financial institutions are often reticent to provide capital for R&D in the face of uncertain cash-flow projections, low appropriability of private returns and high transaction costs. Current market conditions have also affected access, with fewer IPOs; investors avoiding technology stocks on the Neuer Markt and NASDAQ; investors favouring 'no-tech' stocks on traditional stock markets; and a dramatic reduction of new funds for the VC industry in general and early stage funding in particular. The proposed Basel II regulations are also likely to lead to a credit crunch for SMEs in the technology sector, with R&D classified as a risk factor contributing to lower rating assessments.

In order to allow start-ups and spin-offs to flourish, NTBFs to expand and traditional low-tech companies to turn from defensive to innovative high-tech strategies, access to capital needs to be improved. This will involve increasing the amount of capital available to such firms and improving the operational rules and procedures that govern access. In particular, financial institutions require better information on the activities and performance of start-ups, spin-offs, NTBFs and SMEs in general in order to make better finance and investment decisions. This implies better monitoring of firms' activities, greater standardisation in terms of relevant accounting rules, better technology rating mechanisms, and more widespread benchmarking activities. There is also a role for specialist consultants and pedagogic activities geared towards bridging the gap between the financial, business and technical worlds – helping financial institutions to gain a better understanding of technical potential and risks, and helping technically-oriented SMEs to appreciate the realities of both the commercial and financial worlds.

The labour market affects business R&D levels by mediating the supply and demand for highly skilled and qualified labour. In particular, availability and quality are two important factors influencing the location of major R&D facilities. The R&D subsidiaries and development centres established by multinationals in Aachen (Germany), Sophia Antipolis (France) and Cambridge (UK) are testimony to this. But it is not only the share of scientists and engineers in the labour force that influences location decisions. The availability of training opportunities is another important factor, and migration rules which allow bottlenecks in specific skills to be resolved – witness developments in Germany during the IT boom – are also vital. Generally, however, labour market regulations are a constraint on immigration and on internal mobility within the EU. Even if other policies can make the EU an attractive place to conduct research, determined efforts will still be needed to eliminate barriers and harmonise entry rules for highly skilled experts and their families. Headcounts of such personnel would then constitute an important benchmark of progress towards the 3% target.

Overall labour market flexibility also affects technological progress and economic growth generally, which has knock-on implications in the long run for business R&D levels. Labour market practices and social security and pension systems need to be flexible enough to allow the transfer of people from low growth sectors to areas of high growth and productivity. Similarly, educational practices should encourage life-long learning regimes and facilitate the retraining and reskilling needed to ease skill shortages.

3.2 Competition Policy

Competition policy aims to ensure that markets are competitive. Policies in support of R&D and innovation attempt to rectify market failures. They come into conflict with competition policy when they overcompensate and start to distort markets. Knowing where to draw the line between the two spheres is thus critical but problematic.

State aids for R&D in the EU currently identify three stages of R&D (fundamental research, industrial research and pre-competitive development activity) to which different levels of aid intensity apply (100%, 50% and 25% respectively). There are no state aids for innovation that do not correspond to these categories apart from policies which conform with Commission policy on regional investment aid or aid to SMEs (Economic Policy Committee, 2002).

These levels have been criticised on the grounds that the stages do not reflect commercial reality. Their application to individual projects within the context of programmes of state support has also been criticised as over-bureaucratic and inflexible in comparison with systems that maintain specific aid intensities at a programme level but vary intensities within programmes on a case-by-case basis. Counter arguments are that any alterations, e.g. the setting of a uniform level for all industrial R&D at, for example, 50%, would encourage market distortion. These have to be set against claims that state aid regulations in the USA are less harsh, which raises the issue of level playing fields, and against claims that the relatively weak performance of the EU in terms of R&D investment and innovation performance is the cause of poor competitiveness and the consequence, in part, of a market failure which can only be rectified by more generous state aid provisions. The way, forward, therefore, would be to redraw the line by sanctioning a 50% level for business R&D aid intensity. Allowing these levels to be set at a programme level rather than at project level would also allow state agencies to exercise discretion in the concentration of resources in critical areas, whilst maintaining acceptable overall aid intensities. Flexibility and commonsense would then become the key words governing the implementation of state aids.

Within the fields of regional development and support for SMEs, the state aids framework for R&D also distinguishes between various categories of industrial R&D and assigns different allowable aid intensities, but at higher levels (maxima of 50% for pre-competitive development and 75% for industrial research). The case for a uniform level still applies, however, though in this instance the higher level of 75% would be more appropriate. The successful use of Structural Funds to develop scientific and technological capabilities in countries such as Finland and Ireland illustrates the potential of this instrument to engender structural change. Higher aid intensities would increase this potential even further. Undoubtedly this would put pressure on public budgets and affect the competition for resources, but it is still an option that has to be taken seriously if drastic structural change is an imperative and prioritisation and concentration of resources are chosen as the way forward. It will also be important to simplify and streamline the procedures governing decisions on the eligibility of schemes (it took over a year to get clearance for the innovative R&D support schemes initiated by the Greek government under the 3rd CSF) if they are to have maximum impact.

The non-eligibility of aid for innovative activities that do not correspond to the existing R&D categories, unless they conform to SME and regional aid guidelines, should also be reviewed. Successful innovation catalyses future R&D, and efforts to improve innovative performance could have a critical impact on R&D levels. Any reform of eligibility criteria along these lines, however, would have to be preceded by determined efforts to clarify and redefine existing definitions of both R&D and innovation activities.

The role of competition policy apropos of Public Technology Procurement (see Section 4.1.1 for a definition and fuller discussion of this concept) also needs to be reviewed. Procurement of technological goods by the public sector – which can involve specifications requiring R&D if they are to be met – is viewed in many quarters as protectionist in nature and alien to the concept of competitive markets, especially when it leads to a public sector preference for national suppliers. This need not necessarily be the case, however. Empirical studies have demonstrated that the procurement process can be both competitive and highly rewarding in terms of technological change and competitiveness (Edquist *et al*, 2000). Encouraging technology procurement with adequate regulation can stimulate demand for technology and thus improve business expectations in high-tech areas. The US depends upon this model in the defence sector, while the Japanese government has applied it in IT and is currently applying it in the development of magnetic trains.

Competition decisions depend on adequate assessments of market dynamics and competitive conditions. It is important, therefore, that they are based on an adequate understanding of the way in which R&D and innovation function in different high-tech sectors. Conventional wisdom holds that monopolistic and oligopolistic practices hamper efficient allocation of resources, yet in some instances concentration of R&D resources and the attainment of critical mass not only favours innovation but is also a commercial imperative. This has to be appreciated and taken into consideration in competition rulings.

The Commission reviewed the existing Community framework for state aid to R&D in 2002 and decided to prolong it until the end of 2005, during which time it will carry out another review. All the above items should be considered within the scope of that review, even suggestions such as allowing aid intensity levels to be set at a programme level. State aid policy currently aims to control the amount of aid going to individual enterprises and does not allow R&D programme administrations the autonomy to vary these levels within a programme level ceiling. This is in line with the Treaty, which calls upon the Commission to check the compatibility of individual aid projects with respect to individual beneficiaries. If this provision within the Treaty constitutes a serious enough impediment to the attainment of the 3% target, however, the Commission's review should bring this to the attention of the European Council.

3.3 Standards and Regulations

Standards and regulations govern the way we lead our lives. Regulations generally set constraints on behaviour and specify the penalties for not abiding by the rules, whereas conformity to standards can often be voluntary. The standards and regulations that govern the behaviour of industry are numerous and have an enormous influence on innovation-related activities, technological development and competitiveness. They can span fields as diverse as protection of the environment, health and safety and social standards. Those connected with the functioning of product markets are particularly important for R&D and innovation. These include regulations governing prices; barriers to entry; public ownership; constraints on business operation, market structure; and vertical integration.

Standards and regulations can affect R&D and innovation in many ways. In particular, they can either boost or impede innovation. At the beginning of a business cycle, for example, the impact of standards and regulations can reduce risks and generate new generations of products based on these standards, whereas at the end of a cycle standards can lead to lock-ins and frustrate new developments. In the environment field, regulations are often portrayed as constraints on competitiveness and profitability, yet they can also define new lead markets and stimulate innovative activities. A recent UK report[6] cited two examples of environmental policies that had successfully stimulated technological developments and led to environmental improvements. Both involved regulatory changes and the subsequent introduction of best practice technologies to reduce air and water pollution, the most striking of which was the fall in lead tailpipe emissions following the introduction in 1986 of lead-free petrol in the UK. In California, zero-emission demands for cars have also led to accelerated progress in the development of fuel cell technologies. The historical record suggests that much of the innovation prompted by regulatory change in the environment field is modest and incremental in nature but, as René Kemp has noted,[7] stringent regulatory changes, e.g. product bans, can induce more radical innovation.

Great care is needed, however, in the framing of regulations, for there is growing evidence that reduction of the overall regulatory burden on firms can lead to improvements in product markets and have positive effects on innovative activity

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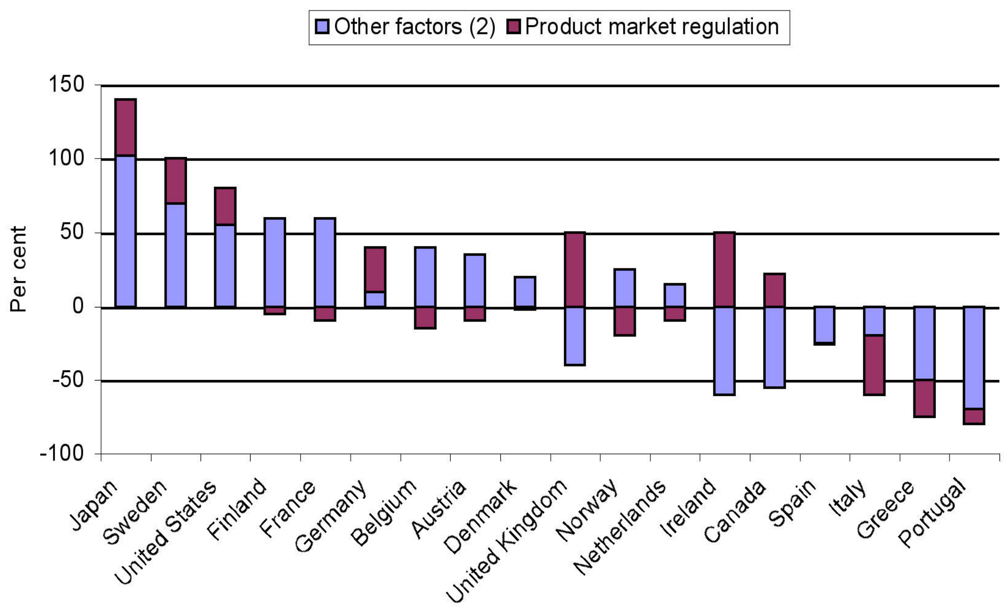
[6] Anderson, D. *et al* (2001), Innovation and the Environment: Challenges and Policy Options for the UK, London: Imperial College Centre for Energy Policy and Technology and the Fabian Society

[7] Kemp, R. (2000), 'Technology and Environmental Policy: Innovation Effects of Past Policies and Suggestions for Improvement', in OECD (2000), Innovation and the Environment: Sustainable Development, Paris: OECD

and R&D intensity. Empirical work by the OECD suggests that, by affecting the incentives to innovate and improve efficiency, regulations that limit product market competition (e.g. by imposing entry or operational restrictions) can have important negative effects on innovation, technology diffusion and multi-factor productivity performance. Conversely, as depicted in Exhibit 3.1, regulations that promote competition can explain more than a third of the excess R&D intensity in the US, Japan, Germany and Sweden relative to the OECD average and provide a large positive contribution in the UK, Canada and Ireland, whereas the opposite effect is strong in Italy and Greece – countries in which regulatory restrictions on competition accounted for one third and two thirds, respectively, of the shortfall in R&D intensity – and in France and Belgium (Nicoletti, forthcoming).

Exhibit 3.1 The Contribution of Product Market Regulations to Differences in R&D Intensity across Countries

Percentage Deviations from OECD Average (1)



Notes: *1. Adjusted for industry composition*

2. Includes employment protection, other controls, country-specific effects and unexplained residual

Source: Nicoletti (forthcoming)

These results suggest that strident efforts should be made to implement regulatory reforms that promote competition in product markets. This should happen globally, with the EU promoting revised, less onerous European regulations and standards as global solutions, with harmonisation across the internal market a desired first step. Such deregulation in the pursuit of enhanced competition and competitiveness, however, should not conflict with the need for standards and regulations safeguarding and promoting other social goals, e.g. the goals of sustainable development and environmental protection. Trade-offs are involved, but win-win outcomes are still possible if the removal of restrictive regulations affecting product markets is complemented by the careful selection of, for example, environmental regulations capable of stimulating rather than limiting innovation and technical change and creating new lead markets.

The pervasive influence of manifold standards and regulations on R&D and innovation activities, the need to reduce the regulatory burden on firms along a broad front and the countervailing need to ensure that new and revised regulations and standards drive innovative behaviour in new lead markets all demand that regulatory reform is central to the process of raising R&D investment levels. This in turn calls for new ways of incorporating regulatory considerations into policy formulation processes. In this context, the growing interest in cluster policies and technology platforms (see Section 5.4) is to be welcomed, for both of these necessarily involve consultation processes that incorporate discussion of the standards and regulations likely to promote innovative behaviour.

3.4 Entrepreneurship

Spin-offs, start-ups and NTBFs are vital ingredients in the drive to boost R&D expenditure, increase innovation and enhance economic growth. Promoting entrepreneurship is thus an important part of the equation. In general, however, it is accepted that the European market is less entrepreneurially minded than its US equivalent. All the evidence points to a lower propensity of both individuals and financial institutions to take risks. Many lenders/investors and other actors (such as suppliers/customers) also have a negative attitude towards business failures in an entrepreneur's track record, whereas the experience of Silicon Valley is that serial entrepreneurs, many of whom have at least one business failure in their background, are very important.

Broad-based efforts, ideally through joint initiatives of government and business associations, are needed to change these perceptions and attitudes. Part of this involves promoting a broad-based 'culture' which recognises the value of entrepreneurship and encourages its spread, but part also involves changing regulations and disincentives which discourage entrepreneurship.

Broad-based cultural measures include general awareness raising initiatives extolling the benefits of entrepreneurial behaviour, targeted awareness initiatives aimed at financial institutions, promoting business plan competitions, prizes for innovative entrepreneurs, and the inclusion of elements of entrepreneurship in school and university curricula, etc. Entrepreneurship could also usefully be promoted by rewarding innovativeness among local and regional authorities and actors. An example of this is the BioRegio competition in Germany, which provides federal level financial support to innovative regional programmes supporting biotechnology networks.

Regulatory changes include the creation of better incentives for universities and research institutes to make sure that the results of research are commercialised whenever possible. Efforts are also required to streamline the steps needed to gain approval for starting a business, hiring labour, getting environmental approval, etc. and making them more 'user-friendly'. In this context, many potential entrepreneurs could benefit from some of the BEST procedures developed by DG Enterprise of the European Commission. Public administrations in many countries could also use these as a source of inspiration for the simplification of the procedures needed to establish new business ventures.

Once established, new high-tech companies also need continued support if they are to flourish and avoid early bankruptcy. Many of these fall under the heading of conventional SME support measures. Others fall more easily into the category of R&D and innovation support measures. In many instances, however, they need to be delivered as complementary parts of support packages aimed specifically at fledgling high-tech SMEs. An example of one such package is given in Exhibit 3.2.

Exhibit 3.2 The Finnish SPINNO Programme

The SPINNO programme was established in 1990. It is a joint venture of the scientific institutions, technical research centres, public authorities and business community in the Helsinki metropolitan area. Its objective is the creation of employment via support for innovative high-tech companies.

The objectives of the scheme are twofold:

- Foster the creation and growth of firms in close co-operation with research organisations;
- Develop an efficient system to evaluate, develop and internationalise complex knowledge based company concepts.

It aims to create 40 to 50 new high-tech or knowledge-based companies per year. The main target groups are researchers, graduate students and vocational school graduates working in scientific and technological areas.

Spinno helps new entrepreneurs to develop their ideas into a company or to license them. It helps to identify the resources needed and to estimate the profitability of the project. The Spinno programme scheme is divided into three phases:

- **Phase 1** is the evaluation programme**,** in which the idea, a tentative business plan and preliminary market research are elaborated and studied in detail;
- In **Phase 2**, a select number of entrepreneurs from Phase 1 follow a six month business training and consulting programme which focuses on: the development of a business plan; new venture management; economic issues; marketing and sales skills; legal issues; licensing etc. Entrepreneurs are given the opportunity to use consultants and students to conduct market surveys and analyses. During the business-training period, the business plans are re-evaluated, companies established and seed financing considered.
- **Phase 3** is aimed at companies seeking international markets. The Spinno international training programme helps companies to develop internationalisation strategies. Companies again have the possibility of using consultants, students and mentors to conduct market surveys and analyses.

SPINNO offers several forms of support to the newly formed companies:

- **Training** is one of the core elements of the programme, not only at the initial stage but also during attempts to internationalise);
- Customised combinations of **government grants and other methods of support (technical, etc.)** are available to set up a new company. **Venture capital** is available through Spinno-seed Ltd.;
- External **consultants and experts** can be hired on a limited basis. Legal services are used most frequently by companies;
- A **support and advisory programme** is available in which companies are assisted by sponsors who are experienced business leaders;
- The **Spinno club** provides an opportunity for networking and co-operation between companies;
- **Accommodation** can be provided in one of the science parks in the area. Participating organisations can also provide them with laboratory space;
- **Leave of absence** can be granted to researchers wishing to start a new company;
- Flexible rules regarding the transfer and payment of **intellectual property rights** help foster start-ups by researchers.

3.5 Intellectual Property Rights

Intellectual Property Rights (IPRs) seek to encourage R&D and innovation via the offer of monopoly rights during a period in which investments in R&D can be amortised. Even though such monopoly rights can hamper diffusion and reduce the efficient allocation of resources in an economy, the inducement they offer to innovate acts as a counterbalance. From a policy perspective, the trick is to find IPR regimes in which the collective good resulting from a healthy flow of innovations outweighs the disadvantages of the limitations they place on the diffusion and exploitation of knowledge and technology.

Problems with the IPR framework in Europe are clearly evident and require urgent attention from legislators and policy makers, and from bodies responsible for the operation or governance of knowledge producing organisations in the public sector. Such problems can be broken down into two major categories: the creation and use of IPR on the one hand – so-called process problems; and problems arising from the involvement of public research organisations (PROs) and higher education institutions (HEIs) – many of which are often new to the process of seeking IPRs – on the other hand.

The most significant process problems for European firms are those stemming from the absence to date of a Community Patent and from the slow process of harmonising European and national arrangements with the rest of the world.

The benefits of IPR have to outweigh the costs of obtaining and enforcing them. It is important, therefore, for IPR regimes to be simple, inexpensive, fast and efficient. In Europe, although this may be the case within some national settings, the historical lack of a Community Patent has made the process of seeking and enforcing protection in successive national markets arduous, time consuming, expensive and inefficient. The recent decision to go ahead with a Community Patent is therefore to be welcomed. In future, the costs of **seeking** protection via a Community Patent should be comparable to those associated with the current European patent, since filing, examination and granting procedures will be similar (though translation costs after grant should be less since English will be the sole language), but **enforcing** protection should be much cheaper and simpler since this will be centralised. To date, lack of a Community Patent has limited the potential of IPR to act as a stimulus to innovation and increased expenditure on R&D. In future, this barrier should no longer exist.

The lack of a Community Patent also had an adverse effect on the development of high-tech capabilities in Europe in comparison with the situation in the USA. The USA had a favourable regime for IPR that offered, and still offers, protection in the largest market in the world. For US-based firms in their home market, there is little doubt that the national IPR regime had and continues to have a stimulating effect on indigenous R&D levels. EU-based firms often patented in the US too, and the protection this gave in this market undoubtedly stimulated some R&D activity in European settings, but for many EU-based firms these incentives were less than they would have been if a Community Patent had been on offer. Firms operating in large national markets with efficient IPR systems (e.g. Germany) were less affected by the absence of a Community Patent, but for many firms operating in much smaller national markets with inefficient or ineffective IPR regimes, the incentive provided by IPR to undertake R&D and to innovate was much reduced.

The involvement of PROs and HEIs in the exploitation and generation of research results and their consequent interest in IPR issues has implications for R&D

expenditure levels. IPR regimes can, on the one hand, offer the same incentives to innovate and increase R&D levels as they do for private sector firms. Conversely, the involvement of public sector personnel in commercialisation activities and spin-offs can act as a drain on teaching and more fundamental research activities and undermine the traditional role of universities and public sector research institutions. At the level of the research system, policies should therefore attempt to find a balance between the continued need to protect the publicly funded mission of research and teaching institutions and the desire to exploit results with commercial potential. Collaborative projects with industry are likely to play a vital part in determining this balance, but there may also be a key role for intermediary organisations to act as technology transfer interfaces between the public and private sector, allowing public organisations to continue to fulfil their time-honoured mandate.

If public sector research organisations are to play a part in exploitation and technology transfer, however, appropriate incentive structures have to be in place for the personnel within them. Without such schemes, which are gradually being implemented in a number of research organisations in OECD countries, technology transfer activities are unlikely to be successful. This issue is dealt with in more detail in Section 4.3.2, which covers the framework conditions affecting the efficacy of risk capital measures to stimulate R&D and innovation. Key issues include clarification of the ownership of IPR developed by academics, especially when working in collaboration with industry in publicly funded programmes. This is one of the most difficult issues to resolve, however, for there is a tension between the needs of existing industrial partners (who naturally want to own the IPR) and those of academics eager to reap some reward for the exploitation of their intellectual capital. One promising solution is for the Commission to develop a template for a default agreement that could be adopted within both national and EU programmes, with all parties obliged to accept this agreement unless they can negotiate alternative agreements prior to the initiation of collaborative R&D activities.

Apart from the issues already mentioned, there are many other areas where considerations of IPR are likely to affect R&D levels in the EU. The vexed question of protection for software needs to be laid to rest if innovation in this sphere is to continue to drive economic growth, and a multitude of patenting issues concerning genetically modified organisms (GMOs) also have to be confronted and resolved. Another topical issue concerns developments in genetics and biotechnology and, specifically, patenting behaviour in areas with ethical overtones. There is little doubt that the huge potential for eventual commercial gain in areas concerned with cloning human beings, germ line modifications and the use of human embryos will stimulate more effort in the USA than in the EU – which limits patentability for the processes involved in these areas. The debate here, however, centres not so much on missed opportunities to raise R&D levels but on the ethical and social acceptability of such patenting behaviour in a European context. As such it is a political issue that merits considerable public discussion and debate before patenting in this area is condoned or rejected.

A further topic that deserves attention concerns the balance between IPR as an incentive to innovate and conduct R&D, and IPR as a constraint on diffusion – which can occur when IPRs are extensive and ill-designed and competitive pressures induce firms to adopt innovation strategies aimed at eliminating competitors or pre-empting the entry of new firms. A favourable policy environment for innovation is one that strikes the right balance between *ex ante* competitive pressures and *ex post* protection of IPRs.[8] In the EU as a whole, low absorptive capacity and the slow diffusion of technologies within low-tech industrial structures are major deficiencies of the EU innovation system that have a major knock-on effect on R&D levels. Rectifying this situation is a policy imperative that warrants further study of appropriate combinations of policy levers. These might include: direct measures promoting the diffusion of protected research results; subsidising protection costs; subsidising litigation costs; brokerage and intermediation schemes; and support for licensing agreements.

3.6 Human Resources

Achieving the 3% objective will require an increase in the number of qualified researchers and engineers (QREs). Available studies and data show that the supply of these QREs could prove a serious bottleneck to the growth of European research efforts in the short, medium and long term. Despite the fact that the share of the workforce with a HEI degree is growing, and that the supply of European graduates from all disciplines within equivalent age groups is higher than in the US and only slightly behind Japan, the proportion of researchers in the workforce in the EU is just two thirds that of the USA and Japan. At present growth rates, the EU will not catch up.[9]

Already today there are serious shortages of QREs in Europe. This picture varies considerably between countries and between fields of research, and in some areas there appears to be an oversupply of researchers relative to job opportunities (e.g. biology in France), but in general demand outstrips supply.

There are various reasons for the shortage of QREs:

- Science and engineering are not as attractive to young people as they once were, and many graduates now choose courses and careers in business and arts. The broad appeal of science in general is thus an issue. If young people have no interest in science, the supply of qualified research talent will dry up eventually;
- The career opportunities and labour conditions (remuneration, pensions, constraints on mobility etc.) for researchers in academia are poor in comparison with those in other spheres;
- There is a gender imbalance in the current pool of researchers, with relatively few women.

All the indications are that Europe is not realising the full potential of its human resources.

In addition, Europe is losing some of its research talent to other continents, particularly to the US. This so called 'brain drain' of QREs to the US is confirmed by data that show that Europe is a net provider of researchers. The US is the main recipient of European researchers going abroad, and 36% of foreign researchers in the US are from Europe. There are various 'push' factors influencing the flow of Europeans to the US – factors stemming from the

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8 See Nicoletti, G. (forthcoming), 'The Economy-Wide Effects of Product Market Policies', OECD

9 See Faegri *et al* (2002), 'Human Resources in RTD: Benchmarking National Policies', STRATA-ETAN Expert Working Group, European Commission. See also DG Research (2001), 'Towards a European Research Area: Key figures 2001', Special Edition, Indicators for Benchmarking of National Research Policies, European Commission

unattractiveness of S&T careers in Europe – as well as 'pull' factors which make comparable careers in the US more attractive.

At the same time Europe is unable to attract similar pools of QREs from outside Europe. Framework conditions such as immigration legislation play a part in this, but the restricted flow into Europe has much to do with the fact that talented, internationally mobile researchers are attracted to centres of scientific excellence, and many of these lie outside of Europe, with US centres the main magnets. Countries with internationalised higher education and research systems operating in an environment conducive to opportunity and reward (e.g. the US outside of the EU and the UK within it) are more successful at increasing the pool of foreign talent in S&T.

Improving mobility inside Europe is one way of providing researchers with more attractive career options. The European Commission has actively supported mobility through its training and mobility programmes and other actions to improve human research potential, but there are still many bureaucratic obstacles, such as large variations between countries in terms of fiscal regimes and pension facilities, which prevent researchers from taking career opportunities abroad. Intra-EU mobility may also have adverse implications for the cohesion and accession countries if return rates are low and net flows are outwards.

In terms of career opportunities for QREs, the fact that many science and engineering graduates choose not to continue in research suggests that the demand-side of the human resources equation is not a strong enough magnet. Improving this situation, however, is complicated by a lack of relevant information and understanding. Apart from analyses in the ICT sector, the data on demand-side needs, particularly in industry, are not as well developed as data on supply-side aspects of the problem. Part of the solution, though, would be to encourage greater interaction between industry and the academic world, particularly via secondments from the former to the latter and *vice versa*. This would improve perceptions of needs and opportunities in both communities.

What is also clear is that industry needs researchers trained in an interdisciplinary manner. This stems from the increasingly interdisciplinary nature of the technological solutions being sought in many industrial sectors. Moreover, as some national pilots have shown, broader curricula seem to have a positive effect on general levels of interest in science and engineering amongst graduates.

Key steps forward involve:

- Increasing the attractiveness of European research careers in academia and industry via better labour conditions and a greater focus on research excellence, stimulated in turn by a more dynamic and competitive research environment;
- Improving the image of science, engineering and research amongst the population at large and schoolchildren in particular;
- Developing policy mechanisms to attract talents from outside Europe to pursue their research careers in Europe. These could vary from financial incentives, such as special tax breaks for researchers, to simplified and flexible immigration procedures;
- Involving industry in the development of strategies for human resources, i.e. thinking beyond traditional public-private responsibilities in these matters.

3.7 Public Research

Policies to support public sector research fall squarely within the domain of conventional science and technology policy. Because of important interactions between the public and private sectors, however, the state of the public research sector constitutes a framework condition for efforts to increase private sector R&D spend.

The commitment to raise GERD to 3% of GDP in the EU calls for the public sector to provide at least 14–24% of the additional investment needed – an estimated €13– 41 billion extra public sector spend by 2010 (see Exhibit 2.11). This rise in expenditure will have to take place in the context of historically flat levels of public sector research expenditure over the period 1990–2000. Public sector expenditure levels will have to rise by up to 60%, however, if the 3% target is to be met by 2010.

There is little doubt that an increase in public sector research will benefit industry. The history of the US ICT sector illustrates the importance of a strong public research base in generating business innovation. Government-funded public research played a critical role in seeding innovation in many of the technologies which underpin modern ICT systems, e.g. time-sharing; graphics; networking; workstations; windows; RISC architectures; VLSI design generally and parallel computing. Similar examples can be found in the sphere of biotechnology and are expected in nanotechnology.

A strong public research sector can boost business R&D spending in several ways:

- It creates new knowledge that firms can build upon;
- It can act as a human resource feedstock for industry;
- It can perform contract R&D for industry;
- It can attract investments from foreign-owned firms, particularly via the concentration of resources in centres of excellence, which act as a magnet for business R&D investment generally;
- Access to distributed research competence can often facilitate the processes of technology transfer and diffusion, which in turn can generate a demand for more public and private R&D.

Key issues relevant to boosting business R&D are thus:

- Finding modes of research funding and operational practices which raise excellence levels both generally and in specific areas of strategic interest;
- Finding the right balance in the public sector between research which is of immediate commercial interest to firms, work of a more fundamental nature (in the case of universities), and work of particular relevance to a diverse array of policy spheres (in the case of government laboratories);
- Promoting interactions between the public and private sectors which promote the flows of both knowledge and people;
- Creating a public research infrastructure in the EU that has an appropriate balance between centres of excellence with the critical mass to act as growth poles for academic-industrial R&D conglomerations and the dispersed research capabilities needed to facilitate technology diffusion.

All these issues demand that choices are made and priorities are set, and policymakers cannot accomplish these tasks either in isolation or via consultation with public sector representatives alone. The business world and other major stakeholders need to be involved in the process. This calls for a greater emphasis on inclusive foresight exercises and policy formulation processes designed to determine strategic choices in the light of the needs and competence of multiple sectors of the community.

Efforts to reform public research systems in Member States will also have to intensify. This will involve raising the status of researchers; improving incentive structures for public researchers to consider the innovation potential of their work and to collaborate with industry; and the removal of administrative and legal obstacles impeding the involvement of universities and researchers in the development of partnerships with industry.

Finding policy solutions will also be exacerbated by the current fragmentation of the public sector research infrastructure in the EU. It will not be enough for individual Member States to follow paths of incremental change within their own national boundaries. Questions of balance and critical mass will have to be addressed at a European level if radical increases in R&D investment are to occur across the EU. This will call, for example, for the reformation of national R&D programmes to eliminate barriers to transnational collaboration between public R&D institutions in different countries, and to cross-border technology transfer between the public and private sectors. It will also call for new institutions such as the European Research Council proposed by EURAB,[10] and for new initiatives to strengthen the university sector across the EU, e.g. transparent and comparable accounting systems and new Europe-wide competitions to promote research excellence.[11] Determined efforts to resolve some of the political tensions that will accompany any move to concentrate research resources in a much smaller number of truly large-scale and global centres of excellence will also be needed.

[10] EURAB (2003a), 'European Research Council', EURAB Advice 2001 – 2002, Luxembourg: European Commission

[11] EURAB (2003b), 'Some Issues Affecting the Future of University Research in the ERA', EURAB Advice 2001 – 2002, Luxembourg: European Commission

4.0 Focused Policy Solutions: Financial and Fiscal Measures

Within the context of Holistic Policy solutions, policy instruments affecting framework conditions have to be deployed alongside sets of more focused financial and fiscal instruments. This Section explores the use of Direct Measures, Indirect Fiscal Measures and two Catalytic Measures: namely Risk Capital Measures and Guarantee Measures. Within separate sub-sections devoted to each of these instruments, their specificity, potential impact and relative importance are explored before reviewing how their use is influenced by framework conditions. Examples of good practice, novel approaches and the lessons that can be gleaned from their deployment are then summarised, together with guidelines for their future use.

4.1 Direct Measures

4.1.1 Specificity, Potential Impact and Importance

The Spectrum of Direct Measures

As noted in Section 2.3.2, when discussing support for **private** sector R&D the term **Direct Measures** includes **Direct Financial Measures**, which involve the direct transfer of financial support for R&D from the public to the private sector via grants, conditional loans etc., and **Other Direct Measures**, which do not involve the direct transfer of finance for R&D projects from the public to the private sector but do involve public sector contributions to schemes providing other sorts of support to firms, e.g. access to advice, brokerage schemes, funding for networks etc.

The term Direct Measures is also used when discussing measures that support R&D in the **public** sector, e.g. the provision of funds for university research (see Section 3.7). These benefit universities directly but, because of interactions between the industrial and academic research worlds, they are also of **indirect** benefit to private sector research actors.

This section deals with all of the above measures. It therefore covers measures as diverse as subsidies and grants, including grants that are repayable in the event of successful commercial exploitation (conditional loans), public procurement and block funding of public institutions. Examples of the range relevant to the task of stimulating increases in private sector R&D expenditure are given below and summarised in Exhibit 4.1.

Support for Public Research Directed to Industry

This includes support for public sector scientific institutions, including universities and laboratories, with conditions attached to increase the benefit to industry. These range from prioritisation of areas of interest to industry, grants conditional upon collaboration with firms, arrangements for use of equipment belonging to either party, and incentives and awards for collaboration. Public laboratories carry out increasing proportions of contract research for industry, extending the range of industrial R&D and potentially bringing R&D to firms without the capability to do it themselves. These measures are a policy priority for most countries and there is ample evidence of the economic value of academic research.

Exhibit 4.1 Direct Measures of Direct Relevance to Raising Private Sector R&D Levels

Direct Measure	Deficiency Addressed	Comment on Application
Support for Public Research Directed at Industry	Resources Incentives Capabilities Opportunities	Includes support for public sector scientific institutions with conditions attached to increase the benefits to industry.
Support for Training & Mobility	Resources Capabilities	Covers the basic production of graduates, tailored courses for firms, training in entrepreneurship and innovation skills, promotion of secondments and employment subsidies for firms recruiting of researchers.
Grants for Industrial R&D	Resources Incentives Opportunities	Evolution away from support of near-to-market research, large firms and single companies in favour of support for SMEs and for collaborative, 'pre-competitive' R&D.
Co-location Measures	Opportunities Incentives	These increase innovation via co-location of industrial and scientific organisations and critical mass effects.
Information and Brokerage Support	Capabilities Opportunities	Support for contact, patent and technological development databases, advisory services, technology transfer offices, brokerage events etc. Primarily directed at SMEs.
Networking Measures	Opportunities Capabilities	Support for information exchange clubs, foresight programmes etc.
Procurement	Incentives Opportunities	Especially Public Technology Procurement i.e. procurement that requires R&D prior to the production of a specified good or service.
Systemic Policies	Resources Incentives Capabilities Opportunities	Policies that deploy multiple policy instruments in a coordinated fashion to remedy multiple deficiencies in innovation systems. Often aimed at 'clusters' of innovation stakeholders.

Support for Training and Mobility

In this category are tailored courses for firms at graduate schools, training in entrepreneurship and innovation skills, promotion of secondments from science to industry and *vice versa*, and employment subsidies for the recruitment of researchers by firms.

Grants for Industrial R&D

During the 1980s, grant schemes were large scale and widespread. A gradual evolution has seen governments moving away from support for near-market research, large firms and single company support in favour of support for SMEs and for collaborative, 'pre-competitive' R&D. Conditional loans are a variation on grants. Evaluations have generally shown a positive impact from such schemes. However, public spending constraints limit their gearing for industrial R&D and such funding has tended to decline at a national level:

- The principal value of grant schemes is that they can be fine-tuned to stimulate firms to carry out R&D either in particular ways or in particular areas, e.g. collaboratively or in areas involving higher risks than firms would otherwise be prepared to take. Their main weakness attaches to the selection process, which may be costly and less attuned to the market than companies' own decisions (the so-called 'picking winners' problem);

  - Increased use has been made of general technology development programmes emphasising support for SMEs, though many measures also continue to be open to large firms and remain dominated by them in sectors such as aerospace, transport and energy. One trend has been to exploit and develop linkages between firms, sometimes along supply chains. Many types of actor other than firms can be involved in projects, including organisations from the science base and technology users. This variety of actors is also reflected occasionally in schemes sponsored jointly by two or more ministries or agencies (a research council, for example. might fund an academic partner, while an innovation agency funds an industrial partner in the same project). This is an increasing trend as countries attempt to increase the flexibility of their innovation support systems and recognise the existence of shared problems and the need to avoid duplication in their solution;
- Reimbursable loans are most relevant for nearer-market R&D (e.g. prototyping) where the risk profile is clear and intellectual assets may be used as collateral. They are nevertheless inappropriate for large firms, which generally have sufficient access to capital to meet their R&D financing needs. Another disadvantage from the point of view of the public sector is that is there is often little incentive for firms to declare success, since this makes their loans liable for repayment.

Co-location Measures

These seek to increase innovation through the proximity of industry and science and critical mass effects. In terms of public measures, they include the provision of facilities for company labs on campuses and the establishment of incubators, science parks and technology parks. The total amount of R&D taking place in such environments is relatively small, but it is important in terms of generating new firms that may subsequently grow into larger entities.

Networking Measures

These include support for clubs exchanging information and for activities such as foresight programmes, which aim to develop common visions around which future oriented R&D networks can be formed.

Information and Brokerage Support

These include support for databases of contacts relevant to innovation-related activities, advisory services, provision of information on technological developments in other countries, technology transfer offices, the organisation of brokerage events, access to patent databases and funding for demonstrators. These schemes are almost exclusively targeted at SMEs lacking the capacity and competence to carry out such activities on their own.

Procurement

This includes Public Technology Procurement (PTP), the situation that arises when a public agency places an order to another organisation for a product or service that does not yet exist. This means that R&D and innovation have to take place before delivery. The procurer specifies the functions of a product or system but not the product as such. This policy instrument is normally appropriate for large-scale systems and is thus suitable for large as well as small firms. Measures to stimulate innovative procurement between private organisations in a supply chain are also possible, as are measures involving the procurement of R&D by government from industry.

Systemic Policies

These policies, for example cluster policies, aim to stimulate and strengthen the links and interactions between the dependent actors in particular innovation systems. They comprise packages of many of the policy instruments discussed above plus, on occasion, a range of other instruments, with the precise combination of instruments determined after analysis of the strengths and weaknesses of the innovation system in question. Effective cluster policies can stimulate private investment in R&D by increasing awareness and confidence among firms, lowering the risks associated with innovation, and strengthening linkages between global players and their actual or potential sub-contractors, including those further along supply chains.

The Role of Direct Measures

Although R&D tax measures are commonplace in many countries, Direct Measures are more numerous and diverse. Their cumulative effect is to raise the quantity and quality of R&D in Europe and they have the potential to play an important role in raising business sector R&D in the EU to a position of at least shared world leadership. Public support for private R&D provides firms with incentives, capabilities and technological opportunities as well as resources, while keeping EU and national innovation systems more adaptable and connected than they would be without intervention.

Their overall impact on raising R&D levels, however, is invariably enhanced if they are used in combination with other instruments. This is best illustrated by reference to the role they can play vis-à-vis other instruments in two specific contexts, namely:

- Raising R&D levels in cohesion and accession countries;
- Motivating MNCs to locate/expand R&D capacity in the EU.

Raising R&D Levels in Cohesion and Accession Countries

R&D expenditure levels are very low in many Cohesion and Accession countries. Attempts to increase these levels via the use of Direct Measures alone, however, are unlikely to succeed. Other deficiencies in their national innovation systems also have to be tackled in parallel. Some of the most important steps involve:

- The use of fairly conventional direct financial measures such as industry-oriented collaborative R&D programmes;
- The promotion of networking and improved collaboration and communication among SMEs and between industry and academic research performers, intermediary organisations and financing organisations;

- The use of fiscal incentives to stimulate R&D along a broad front;
- The acquisition of skills in research and innovation management, exploitation of research results, and technology and know-how transfer;
- The promotion of an innovation culture and strategic, long-term and 'international' thinking amongst SMEs;
- The adoption of evaluation, assessment and foresight approaches (strategic intelligence in policy-making) in order to optimise the use of limited resources (human, monetary and infrastructural);
- The adoption of clear and co-ordinated science, technology and innovation policies based on thorough analyses of their national innovation systems.

The need to promote an innovation culture is particularly important in many of the cohesion countries, since any increase in business R&D in these countries will depend on the degree to which local business culture accepts and adapts to the need for innovation. In terms of increasing private investment in R&D, Direct Measures encouraging firms to become involved in R&D and to collaborate with research organisations may only have limited results. To be effective, they need to be complemented by actions designed to make firms aware of the opportunities, threats and even the necessity of innovating, entering new, more innovation-demanding markets and 'going international'.

In some accession countries the problem is even greater. Here the challenge is to find technology-based firms with sufficient resources and vision to look beyond the struggle for day-to-day survival and the courage to begin the virtuous cycle of investment in innovative activities. Building links with existing research institutions may also complicated by the fact that traditional competence in this sector may be out of alignment with the needs of firms involved in rapidly changing technology sectors. There may be overcapacity in some physics and materials-based sectors, but not in sectors such biosciences.

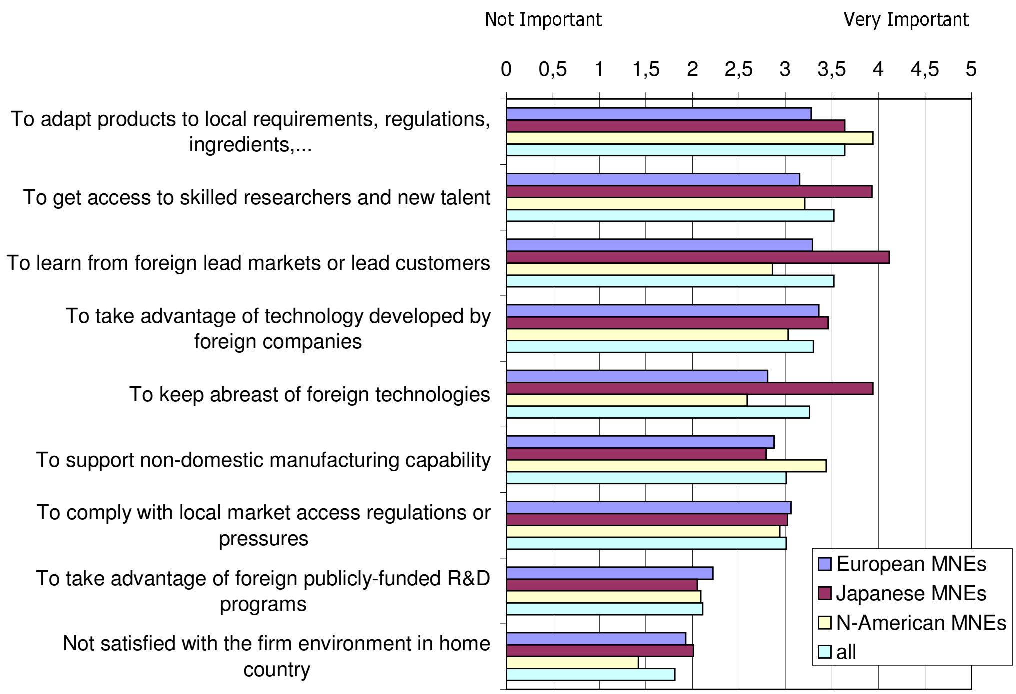
In order to take full advantage of direct measures, they need to be located within broader packages of support measures. In turn, these need to be conceived and implemented within the context of national innovation policies aimed at providing support at national and regional levels for the promotion and development of innovation in local industries and SMEs. Such overarching policies are missing in most accession countries and in many cohesion countries, despite their long membership in the EU. Greater efforts are therefore needed to analyse innovation system strengths and weaknesses, to involve industry and other stakeholders in priority setting, and to coordinate the formulation and implementation of national and regional science, technology and innovation strategies across all ministries with a vested interest in a healthy innovation system.

Motivating R&D Investment by Large Firms

As noted in Section 2.2.1, one of the most effective ways of raising R&D levels within the EU would be to persuade the largest R&D performers in the world, i.e. MNCs, to locate more of their R&D capacity in the EU. Direct measures can play a part in this, though only in conjunction with other measures. In terms of attracting internationally mobile R&D investment, subsidies (and, for that matter, fiscal incentives) are factors that only come into play at the margins. Once research capacity has been established, however, initiatives such as collaborative R&D programmes provide access to the science base and can play a significant role in retaining footloose investment.

The results of a survey of Triad companies (Exhibit 4.2) illustrate the range and importance of motivations for investing in R&D abroad (Edler, Meyer-Krahmer and Reger, 2002). The three strongest motives for the **European** companies were to take advantage of technology developed by foreign companies, to learn from lead markets/customers and to adapt products to local needs. For **Japanese** companies, learning and generating knowledge abroad were more important. They wanted to learn from lead markets/customers, to keep abreast of foreign technology and to have access to foreign researchers and talent (confirming Granstrand, 2000). **North American** companies were strongly motivated by the need to adapt products to local requirements, to support non-domestic manufacturing capability, and to gain access to skilled researchers.

Exhibit 4.2   Motivations for MNCs from the Triad Regions to Invest in R&D Abroad



Source: Edler, Meyer-Krahmer and Reger (2002)

Important points for EU policymakers to note are the lower rankings given by firms from all three regions to disaffection with framework conditions in their own countries and to the desire to take advantage of foreign publicly-funded R&D programmes. Firms do not seek to locate R&D capacity abroad for negative reasons, nor out of a desire to seek subsidies. Publicly-funded R&D programmes are important inasmuch as they improve the R&D and technological and innovation capacities of regions, which are important magnets for foreign firms, but the prospect of participation in the programmes themselves is not an important magnet attracting foreign R&D capacity (though it does play a part in its retention). The principal factors affecting inward R&D investment decisions are proximity to key markets, the availability of skilled researchers, and access to the general knowledge infrastructure. Hence the most important policy measures are those which strengthen European markets by removing barriers, those which lead to greater numbers of highly skilled people, and general investment in high quality science and technology. In addition, it is important to stimulate the quality and scale of demand via regulation and/or procurement in order to create 'advanced demand' or **lead markets**. A lead market is one in which a company is motivated to research, develop and introduce innovative goods that will eventually be introduced to other markets.

Implementing Procurement Policy

The potentially powerful role procurement policy can play in creating lead markets and raising R&D investment levels in the EU deserves special mention. Historically, the public procurement of goods and services has been a major instrument of innovation policy, though it has not been emphasised in recent years. There are three main types of procurement policy, two of which involve R&D:

- 'Regular' procurement, where ready-made products are bought 'off-the-shelf' and where no R&D or innovation is involved;
- Procurement of R&D directly by government in support of its own needs, which normally involves R&D in support of policy and regulation;
- Public Technology Procurement (PTP), defined earlier to be procurement that necessarily involves an element of R&D and innovation to produce the product or service specified by the customer.

Under the right conditions, policies for public procurement of R&D in support of the many functions performed by government (policy development, legislation, regulation etc.) can be leveraged to increase levels of R&D expenditure, for example by encouraging research contractors to develop spin-off innovations based upon the research findings. The instrument with the greatest potential for raising private sector levels of investment in R&D, however, is Public Technology Procurement.

Public Technology Procurement

The potential of this policy instrument is very large. EU figures indicate that €720 billion or 11% of the EU's GDP is spent annually on public procurement. While most of this is currently for 'off-the-shelf' products, many areas offer scope for a greater emphasis on innovative products. A change of emphasis of this type, e.g. a requirement that 5-10% of all public procurement contracts should contain an innovation or R&D component, could attract significant new resources for innovation and hence for R&D.

PTP is dependent upon close relations between buyer and seller and the development of mutual learning. Because of the risks of anticompetitive behaviour, such collaboration is no longer encouraged except in the defence sphere. There is a strong case, however, for a new trade-off between the maximisation of competition and the promotion of innovation. The UK's Smart Procurement Initiative in the defence sector is one instance where the sponsors stepped back from a fully competitive market model after realising that the public interest is not served by the excessive transfer of risk to contracting firms unable to bear that risk. This type of partnership model could be broadly extended, but it requires government agencies either to possess, or to have access to, high levels of expertise in the technology, innovation and industrial domains concerned. In particular, the public sector itself needs to conduct R&D in these areas if it is to become an 'intelligent customer' able to formulate realistic and informed technological specifications. Over recent years, however, intelligent purchasing capability within government has been eroded in many countries and will need to be rebuilt, which in turn will require increased expenditure on R&D by the public sector as well as the private sector.

Successful Use of PTP in Telecommunications

The Nordic countries have successfully used PTP to strengthen national R&D and technological and innovation capacity. One example was the development of the first digital switching technology, the AXE system, which was procured by Televerket (the public telephone monopoly at the time) and supplied by Ericsson. This created a strong comparative advantage for Ericsson that lasted for decades (Fridlund, 2000).

After the NMT 450 mobile telephony standard had been developed by the Nordic PTTs, the Swedish PTT used this standard in deriving a functional specification for four orders for mobile systems (which did not exist at that time). One of these orders led to the development of the first digital switch for mobile telecoms, developed by Ericsson and based on the AXE system. Ericsson was reluctant at the time to start this adaptation of the AXE and had to be encouraged to do so by the PTT (Lindmark, 2002; Edquist, 2003). PTP played a similar role in the development of the Finnish mobile telecommunications equipment producing industry (Palmberg, 2000).

Defence R&D

Public Technology Procurement is most widespread in the defence sector. Defence is an area of very substantial equipment procurement and, in some countries, of continuing large-scale government spending on industrial R&D, despite the cutbacks since the end of the Cold War. Attempts over recent years to develop dual use technologies that allow the results of R&D to be exploited in the development of both civil and defence-related technologies have focused upon reducing the R&D burden and improving the productivity of R&D, rather than increasing the share of R&D within the defence sector *per se*. The high costs of defence R&D and the relatively enormous expenditure of the USA have put pressure upon European governments and defence contractors alike, and one way forward has been via economies of scale achieved through international collaboration and industrial restructuring. For example, Defence Ministers in six European countries have launched an initiative to promote these outcomes through the Letter of Intent/Framework Agreement process. In particular, harmonised requirements and cooperative solutions to defence technology problems are being sought, with efforts being made to address barriers such as security concerns and intellectual property rights. Similarly, the Organisation for Joint Armament Co-operation (OCCAR) is an international European Agency involving France, Italy, Germany and the UK. Its mission is to become the best international defence procurement agency in the world via the application of principles such as the renunciation of *juste retour* and determined efforts to harmonise requirements across the countries involved.

A specific case in defence procurement is the direct funding of R&D for military needs. Probably the best-known agency in this respect is the US Defense Advanced Research Projects Agency (DARPA). With a FY2003 budget of $2.7 billion (€2.4 billion), this agency's mission since 1958 has been to ensure US leadership in military technology. A small, flexible and non-bureaucratic central office develops topics for funding and selects projects from contractors drawn from industry and often universities. Typical projects are in the range of $10-40 million (€9-35 million), though many are smaller. As a government funding agency, it is unusual in that it is able to support a technology area from academic research through to commercial success without gaps, so long as there is a clear defence objective (Etzkowitz *et al*, 2001).

Smart Procurement – UK Ministry of Defence

The UK Ministry of Defence spends around €14 billion per annum on procuring and supporting military equipment. A Strategic Defence Review highlighted a need for radical changes in defence procurement to avoid long and costly delays in major programmes. Among the weaknesses identified were the transfer of commercial and technical risks to contractors unable to absorb these risks, and delays in decision-making involving collaborative projects. A particular weakness was the failure to strike the right balance between cost, time and performance in the very early stages of projects. Insufficient investment in risk reduction at this stage proved very costly later on. Other weaknesses included a tendency to use the same approach to procurement for widely differing projects, a failure to delegate sufficient authority to project managers, and failure to provide properly targeted incentives to both contractors and staff.

To address these problems, a revolutionary approach known as the Smart Procurement Initiative (SPI) was introduced. This aimed to deliver projects on time and to cost through organisational, staff-training and procedural changes in acquisition behaviour. Included among the changes were the adoption of separate procurement approaches for major and minor projects and for commodity and other low risk items. Of particular relevance was a move away from competitive tendering towards formal partnering arrangements with industry – arrangements that provided firms with significant incentives to perform well and share the benefits. When new projects are conceived, industry helps to establish technical feasibility and to estimate costs. After tendering procedures have been completed, industry is then represented on Integrated Project Teams that oversee projects for the remainder of their lifespan.

DARPA claims a number of historical successes as a result of its work, including "between a third and a half of all the major innovations in computer science and technology" (Dertouzos, 1997). In particular, DARPA played a key role in the emergence of areas such as microelectronics, computing and network communications and exerts considerable influence on the technological directions taken in defence and non-defence markets. In the early 1990s, this even led to the idea that DARPA might extend its scope beyond defence, with the result that its name was temporarily changed between 1993 and 1996 to its original formulation (ARPA).

The success of DARPA in the US has implications and lessons for the stimulation of both defence and civil R&D in the EU. First, it should be recognised that part of the R&D gap between the EU and the USA stems from the high level of defence expenditure in that country. Programmes such as DARPA, combined with a huge market for innovative goods, provide a major stimulus for company-funded as well as contracted R&D. The restructuring of the defence sector and common procurement in Europe are clearly beneficial approaches, but unless there is a major shift in policy there is no possibility of reaching the US scale of activity. If Europe is to have an equivalent procurement-led technology base, Public Technology Procurement will need to extend to the civil sector. Lessons in procurement practice can be drawn from the defence world, however, including the benefits of flexibility, partnership with industry and the potential for payback on R&D, as illustrated by the DARPA case. Reproducing these conditions in civilian circumstances will nevertheless be a major task, requiring changes in regulations, attitudes and levels of technological expertise in government departments.

4.1.2 The Influence of Framework Conditions

A strong science base is a precondition for the success of many of the joint research, networking and technology transfer activities involving both industry and the academic sector. It creates opportunities for innovation through the production of new knowledge and is the most important source of trained people. It also provides firms with a window on the world of research. Many direct measures seek to increase the leverage of the science base by improving its linkages with business or by supporting commercialisation and the formation of new companies. Recent analyses have illustrated that, despite its many strengths, the science base in Europe is not being fully exploited. In many fields the pattern is one of 'islands of excellence' rather than the strong concentrations that can be found in the USA. This limits economies of scale in equipment and prevents the critical masses needed for interdisciplinarity from developing. It also increases the search and collaboration costs for European industry at a time when major companies are seeking to maintain long-term relationships in both research and training by focusing their collaborative activities upon a smaller group of academic institutions. The implication is that radical restructuring is needed in some science and technology fields via policies based upon selectivity, the concentration of resources and the creation of 'Centres of Excellence'.

Direct measures aimed at increasing private sector R&D levels can only succeed if sufficient high quality researchers are in place to carry out the additional research effort, not to mention the need for a more innovation-aware workforce generally. There are wide variations in the quality and quantity of researchers across the EU, however, and aggregate levels are not improving at a rate likely to satisfy the demands of the 3% R&D target. Policy initiatives along many fronts are needed to rectify this situation. Support for basic science and engineering in universities will invariably have to increase, plus there is scope for additional direct measures that reward the recruitment of new R&D personnel in industry and provide training for industrial personnel in R&D and innovation management.

The success or otherwise of Direct Measures aimed at increasing private sector R&D levels via subsidies for collaborative R&D projects is greatly influenced by prevailing IPR regimes. Regimes that favour academic institutions over industry can deter industrial participation, while the incentives for academics are similarly weakened if the claims of industry are prioritised. An equitable balance obviously needs to be struck, with scope for joint ownership and exploitation. The most important need, however, is for the participants in collaborative programmes to reach speedy agreement on acceptable IPR arrangements.

State Aid regulations in Europe are more restrictive for grant schemes than the corresponding regulations in the USA. They are based upon the outdated linear model of innovation, which ties levels of support to sequential innovation stages that are no longer recognised as distinct. Furthermore, eligibility criteria that bar support for 'core' activities are misguided. They fail to recognise the interrelatedness of different parts of the innovation process within a firm and the fact that definitions of 'core' vary rapidly in turbulent technology and business environments. They also fail to recognise that radical and risky innovation can take place within a firm's area of core competence. More flexible approaches are needed to overcome these deficiencies in the current State Aid regulations.

4.1.3 Good Practices, Lessons Learned and Novel Approaches

Elements of Good Practice

- Direct Measures require a clear rationale in order to ensure that programmes address priority needs. Foresight exercises may help to clarify such needs;
- Larger programmes can be more comprehensive in their coverage and are more visible to industry;
- Cooperative R&D, both between firms and between firms and scientific bodies, can create a critical mass of effort;
- Programmes aimed at broadening the research community by attracting traditional, low R&D-intensive firms and lengthening their R&D horizons usually need to involve advisory and support services as well as the straight provision of finance;
- Widening the set of stakeholders by, for example, involving sectoral ministries increases the scope for R&D devoted to the solution of social problems;
- Ideally, policies or programmes should aim to modify the behaviour of participants permanently to avoid the need for continuing support, though on-going support may be necessary if the need to change is itself continuous;
- Programmes with a mobility element encourage the interchange of personnel between academia and industry and strengthen the likelihood of knowledge transfer.

Elements of Bad Practice

- Excessive administrative overheads for applicants and participants are unfortunately common. These often result from complex application procedures, low application success rates and the over-zealous application of financial viability criteria to SMEs, which at best screen out a few potential failures but at worst deter large numbers from even applying. The latter problem could be mitigated by recognising that accountability has its limits and that the adoption of risk portfolio approaches would be more appropriate. These recognise that a certain proportion of financial failures is acceptable if the costs are less than those involved in administering unwieldy screening systems;
- Large numbers of small grants and low funding levels per project increase the relative overhead costs of participation and reduce the attractiveness of programmes to firms;
- Broad-based programmes spanning many scientific and technological areas can address a large number of needs and interests, but they may also fail to build critical masses and rectify specific weaknesses if the resources are allocated too thinly over a broad population of firms and institutions;
- Procurement of R&D tends to focus almost exclusively on large firms if there are no quotas or other arrangements in place to ensure greater SME involvement.

4.1.4 Guidelines for Future Use

These guidelines distinguish between supply and demand side policies and framework conditions where these involve direct measures.

Supply-side

Many direct measures are now based on rationales that reflect the ascendance of behavioural additionality over the concept of input additionality. In other words, many programmes now reflect the belief that it is as important to influence how R&D is done as it is to influence whether or not it is done at all. Consequently, more traditional direct measures such as grants and reimbursable loans now provide incentives for developing new networks and collaborative linkages and are located within the context of broader strategies such as the development of regional, national or sectoral clusters. These create cumulative technological assets that, in the longer run, enable firms to increase their returns on R&D and, subsequently, to reinvest in further R&D efforts.

Grant-based programmes are often valuable measures in themselves, but there are legitimate concerns about the confusing array of small-scale measures on offer in many national situations. On the other hand, large and inflexible instruments do not adapt to individual circumstances or to changing technological priorities over time. The right mix would appear to be a small portfolio of flexible measures with adaptable rules. There is also a need for policy coordination to ensure that addressing deficits in one part of the system does not create bottlenecks elsewhere.

One aspect of flexibility is currently constrained by the present structuring of State Aids around the outdated linear model of innovation. Where there is a clear rationale for support from public funds, there is a strong case for changing the rules to allow awards up to the current maximum level of support for industry (50%) for any part of the R&D process.

In terms of contributing to the 3% target, measures based upon expenditure of public funds are clearly constrained in their potential to grow by overall budgetary considerations. During the recent growth in industrial R&D, public expenditure on R&D grew at a much lower rate, and in some areas did not grow at all. Now, as business slows its growth in the current recession, fiscal difficulties for many governments are impacting upon the funds available for R&D. The core message to policymakers on this point is that subsidies (and fiscal incentives if they employ countercyclical tactics) are most valuable during a recession. They enable firms to rebuild their technology bases when their own revenues are stretched. They also help maintain research capacity that is easily destroyed but much more difficult to recreate.

The strengths and limitations of R&D support policies should be clearly recognised. Although they have a key role to play in raising business R&D levels, they are often best deployed in conjunction with other instruments. In terms of attracting inward R&D investment, they are best complemented by measures that facilitate access to markets and scientific personnel. In cohesion and accession countries, they are best used in conjunction with measures supporting technology transfer, since possession of an R&D capacity is often the key to successful absorption.

SMEs, particularly those in traditional low- and medium-tech sectors, often do not have the capability to perform R&D either directly or alone. The contract research sector has a vital role to play in compensating for these capability failures. The main challenge for government policy in this area is to ensure that contract research organisations maintain their scientific and technological capabilities via strategic research programmes geared towards this end, and that such organisations act as a focus for networking between companies and universities. SMEs themselves must also be encouraged to perform sufficient technological work to create and maintain an absorptive capacity for external R&D.

The total amount of R&D being performed in Europe is constrained by the definitions in the Frascati Manual. The importance of the service sector and the growth of non-technological innovation (which is often complementary to technological innovation) make a case for redefining the creation of new knowledge by industry and the activities involved in this process. Even if this does not improve Europe's ranking relative to the USA and Japan, recognition of these activities as R&D would be a first step to understanding the conditions and policies that could stimulate its growth.

Demand-side

The main area of neglect in recent years in R&D and innovation policy spheres has been demand-side policies. Certainly many countries have attempted to stimulate aggregate demand via the use of a variety of macroeconomic instruments, but few have actively sought to link supply and demand directly via the use of instruments such as Public Technology Procurement, which creates a demand for R&D and stimulates the development of lead markets. This is unfortunate in that loss of actual and potential R&D investment from Europe has been as much driven by the attractiveness of markets elsewhere as by any factors intrinsic to the performance of research. Other measures that try to link supply and demand include attempts to alter the conditions affecting the private procurement of R&D and efforts to build technology platforms (sometimes called public-private partnerships). These accelerate the emergence of new markets for technology-intensive goods by combining direct measures such as grant support with measures to improve links within supply chains and clusters and efforts to shape new markets via the development of appropriate standards and regulations.

Public Technology Procurement is the most powerful weapon in the armoury of policy instruments needed to achieve the 3% target. With a spend in the EU of at least €720 billion per year, only a small increase in the proportion of resources devoted to goods and services requiring R&D would raise R&D levels significantly in both the short and – via the development of new lead markets – the longer term. The public would also benefit from more innovative public goods.

Specific steps to promote PTP include:

- Acknowledging that public services should also be risk takers, which involves recognising that the failure of some PTP initiatives is both acceptable and justified by the need to stimulate R&D, innovation and new lead markets;
- Requiring governments to produce regular plans and statements on the degree of innovation and technology development involved in their procurement practices;
- Investigating the possibility of declaring target levels of expenditure for the R&D/innovation components of public procurement;
- Investigating possible changes in competition regulations such that they do not obstruct collaboration between procurer and potential suppliers whenever there is a strong innovative component.

Framework Conditions

Greater support for the education of scientists, engineers and researchers is imperative if the 3% target is to be reached. Direct measures also have a supportive role to play via training schemes for industrial personnel and schemes rewarding the recruitment of new R&D personnel in industry.

There is also a need to remove obstacles constraining the mobility of researchers from the public to the private sector and/or their 'dual membership' in both. These obstacles are numerous and diverse. Most countries endorse simultaneous employment in both sectors but some apply time or salary restrictions. The extent to which academics must declare their commercial relations with the private sector to their academic establishments also varies from one Member State to another. Transfer of pensions and social security rights is a problem in some countries too. Entitlements built up over several years in the public sector can be lost or not readily re-established after an extended period in industry. The ability of civil servants to transfer to industry is also restricted in some countries. Measures to promote inter-sectoral mobility include financial support for secondments and relaxation or removal of restrictions arising from the civil service status of researchers.

Continuing support for research in the science base is an essential precondition for a healthy industrial R&D culture. The need for excellence as a driver of competitiveness is clear, though the relationship between an excellent science base and successful industrial innovation is far from automatic. Continuing emphasis upon the whole range of measures that exist to promote industry-science relations is needed, along with complementary measures to train students in entrepreneurial skills and to induce a similarly entrepreneurial culture amongst researchers in academic and other public laboratories.

4.2 Indirect Fiscal Measures

4.2.1 Specificity, Potential Impact and Importance

Indirect Fiscal R&D incentives reduce the costs of R&D for a wide variety of firms, including SMEs, while leaving the content of projects at the discretion of the firms themselves. If well designed, fiscal schemes can help raise overall levels of investment in business R&D.

Fiscal R&D incentives allow companies to reduce their tax payments as a reward for carrying out innovative activities. Most EU-15 countries operate some form of tax measure to stimulate business enterprise R&D, as do Australia, Canada, Japan, the US and China. The use of fiscal incentives for R&D has increased in recent years. Some examples of the types of schemes employed are given in Exhibit 4.3.

Exhibit 4.3 Indirect Fiscal Incentive Schemes for R&D

Measure	National Schemes
Corporation Tax schemes (Volume based)	Italy (only for firms in Objective 1, 2 and 5b areas), United Kingdom (separate schemes for SMEs and large firms), Canada (federal and state level schemes)
Corporation Tax schemes (Incremental)	Belgium (per additional member R&D staff), France, United States, Japan, Korea
Corporation Tax schemes (Mixed systems)	Austria (three parallel schemes), Portugal, Spain (national level and some regional fiscal schemes), Australia
Schemes based on the employers' share of wage tax and social contributions	Netherlands
Fiscal schemes to attract foreign key personnel[1] through personal income tax	Finland, Sweden, Denmark, Netherlands (all have favourable income tax rates)

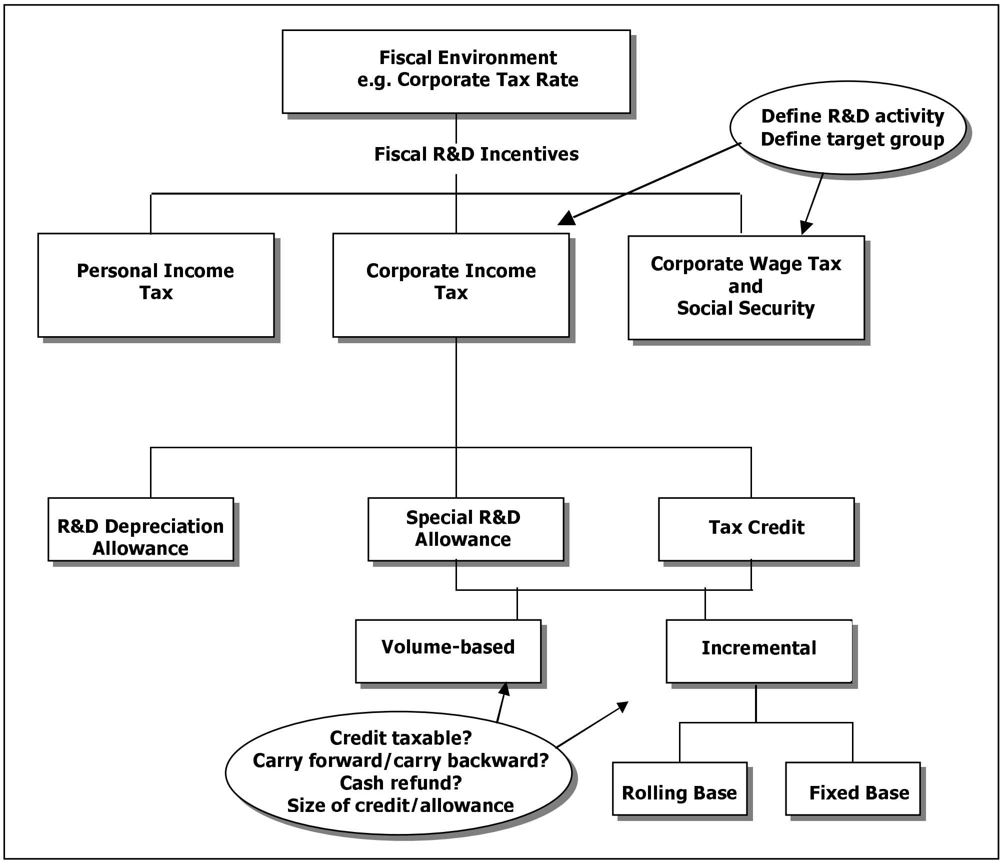
1 These schemes are not exclusively for R&D staff but also include other 'key personnel', e.g. engineers and management.

Fiscal incentives for R&D can be designed in many different ways. The range of alternative schemes is wide and many different factors affect the design of the schemes adopted. Some of the options are illustrated in Exhibit 4.4.[12] The general fiscal environment certainly has an effect on which taxation regimes are most appropriate, with the choice generally lying between schemes variously based on corporation tax, a company's share of wage tax or personal income tax regimes.

For schemes based on corporate wage tax and income tax, design choices involve choosing the target groups (e.g. firms of a particular size, or even firms within particular industry sectors) and specifying eligible R&D expenses (current R&D expenses, R&D labour costs, total R&D expenses, innovation expenditures, collaborative or outsourced research etc.). In addition, the level of fiscal generosity has to be chosen.

[12] The use of VAT as a tax regime for stimulating R&D is also an option.

Exhibit 4.4 The Basic Framework of Indirect Fiscal Incentives for R&D



Schemes based on reductions in Corporate Income Tax as a reward for conducting R&D can be divided into three types. The first category covers **R&D Depreciation Schemes**. These reduce the taxable income of a company via accelerated depreciation schemes for capital invested in the machinery, equipment and buildings used for R&D purposes. The other schemes can be divided into those that reduce the taxable income of a company via allowances (**Special R&D Allowance Schemes**) and those that reduce corporate tax liabilities (**R&D Tax Credit Schemes**). A special R&D allowance makes it possible for firms to deduct more than 100 per cent of their current R&D expenditures from their taxable income. Tax credits, on the other hand, enable firms to deduct a percentage of their R&D expenses directly from their tax liabilities.

Allowances and credits can be calculated using either a flat rate or an incremental rate. A flat rate or **volume-based** tax scheme provides for an allowance or credit equal to **a fixed proportion of the R&D expenditure** in a given year. An **incremental** tax scheme provides for an allowance or credit equal to **a share of the increase in R&D expenditure**. This increase in R&D expenditure can be computed with reference either to a fixed level of expenditure in the past or relative to a rolling base (e.g. the average R&D expenditure over a fixed number of preceding years). The current French fiscal R&D credit scheme, for example, is an incremental scheme based on a rolling base calculation.

In practice, volume-based, incremental and hybrid varieties of both R&D Allowance and R&D Tax Credit schemes are commonplace around the world.

Exhibit 4.5 provides an overview of practices in a variety of settings. In recent years, however, tax credits for R&D expenditures have become more popular than tax allowances.[13]

Exhibit 4.5 Use of R&D Tax Incentives, 2001/2002

	Volume-based	**Incremental**	**Combination of Volume-based and Incremental**
R&D Tax Credits	Canada Italy Korea Netherlands	France Japan Korea Mexico United States	Portugal Spain
R&D Allowances	Belgium Denmark United Kingdom	Norway	Australia Austria Hungary

Source: Adapted from Warda (2002)

Despite their widespread use, not all countries are convinced that fiscal incentives are an effective instrument to stimulate private R&D investment significantly. Primary reasons for this include the complexity these incentives add to general tax regimes and a preference for using targeted support schemes such as collaborative R&D programmes. Finland and Germany are both countries that have decided not to use fiscal incentives.

Generalisations concerning the efficacy of different types of R&D tax incentive schemes are difficult to make in the absence of extensive evaluation studies of fiscal schemes and the methodological difficulties associated with many of the econometric studies undertaken in this area. Nevertheless, the following tentative conclusions can still be drawn:

- **If well designed, fiscal incentives can stimulate business R&D**. It has proven difficult, however, to evaluate the amount of additional R&D generated per unit of tax income forsaken by the public sector. The few tentative evaluations that exist show positive but moderate levels of leverage and additionality, and the possibility of externalities (R&D spillovers) strengthens the likelihood of fiscal incentives having positive impacts;
- **There is a clear need for more formal evaluations** to establish the effectiveness and impact of fiscal incentives, and for greater efforts to improve the methodological tools needed to conduct them;
- **Better micro-level data sets are needed** to understand the long-term impact of fiscal incentives on business R&D;
- Existing evaluations of fiscal R&D incentive schemes in different countries cannot be compared due to the use of different methodologies, incommensurable data sets and dissimilar time periods. **Coordinated, cross-country comparisons of the efficacy of different types of scheme using similar methodological approaches are needed**.

[13] OECD (2002b), Tax Incentives for Research and Development: Trends and Issues, DSTI/IND/STP (2002)1, June, Paris: OECD

4.2.2 The Influence of Framework Conditions

The most obvious framework conditions that affect the working of fiscal incentives are the **relative complexity** of the overall tax regimes in which they are situated (levels of corporate tax and income tax, depreciation rules etc.) and the **relative generosity** of the tax allowances and credits allowed by these systems. Fiscal regimes vary greatly from one EU country to another and R&D incentive schemes vary in line with these.

There is an ongoing debate within the EU about the case for **a common corporate tax base**. At present, the debate centres on the influence of complex, opaque and heterogeneous tax regimes on cross-border investment decisions, including R&D investment decisions. The European Commission's October 2001 Communication (European Commission, 2001a) and the accompanying study on company taxation is currently the focus of the debate. The Communication infers that most of the tax-related obstacles to cross-border economic activity are due to the existence of fifteen tax jurisdictions in the Internal Market. The Communication goes on to advocate targeted solutions to deal with these obstacles in the short term, but calls for a more comprehensive, longer-term approach that provides companies with a common corporate tax base across the EU. This may have consequences in the future for the way Member States design fiscal incentive schemes for R&D, but at this stage it is impossible to comment further.

Direct financial support measures for business R&D can interact with and positively reinforce fiscal incentives for R&D. Fiscal instruments can stimulate R&D investment along a broad front, while direct measures are better targeted at specific actors or technology areas whenever there is the need to rectify weaknesses or build on strengths. If care is not taken, however, both sets of instruments can also interfere negatively with each other, especially if one mechanism decreases the attractiveness of the other to firms. Policymakers need to ensure that fiscal measures and direct government funding of business R&D complement each other. This can only be achieved through an **effective co-ordination mechanism** between the public institutions (ministries and agencies) involved in the stimulation of business R&D.

4.2.3 Good Practice, Lessons Learned and Novel Approaches

Some of the potential advantages of fiscal incentives over direct support instruments include the following:[14]

- Because they act 'horizontally' across a broad range of companies, fiscal instruments are useful when there is not enough strategic intelligence concerning the specific weaknesses and strengths of different target audiences to merit the use of direct support instruments. If targeted incorrectly, direct instruments can lead to unwanted distortions, whereas the risk of this happening with fiscal instruments is less;
- The administrative costs of running a fiscal incentive programme can be lower than those for direct R&D funding programmes;
- Fiscal incentive schemes are more accessible to firms, particularly small firms, than direct governmental support schemes, which invariably involve an element of competition and selection;

[14] See Hutschenreiter (2002), Tax Incentives for R&D in Austria, Vienna: Austrian Institute of Economic Research

- From the perspective of a firm, the potential impact of fiscal incentives on future activities and cash flow can be more predictable than the lottery of direct grants;
- A political argument in favour of fiscal incentives is that they are not regarded as additional government expenditure but as loss of revenue. Whenever there are stringent limitations on the expansion of public expenditure, political support for boosting fiscal incentives might be expected to increase.

On the other hand, fiscal measures also have a number of potential drawbacks:

- Although the absence of evaluation data makes it difficult to say whether or not the levels of leverage and additionality associated with fiscal measures are intrinsically lower than those associated with direct measures, the potential for 'windfalls' on the introduction of some fiscal measures, e.g. volume-based schemes, has to be taken seriously;
- By providing financial support for actual projects, direct measures have an immediate, explicit effect on R&D investment levels, whereas the financial benefits from reduced tax payments are not always felt directly by R&D managers, especially when tax and R&D matters are handled by separate administrative units;
- Greater budgetary control is possible with direct support measures since these are usually endowed with fixed annual resources;
- Because they are 'horizontal' instruments and less amenable to targeting, fiscal instruments are generally less effective at supporting specific government priorities and focusing on research with high societal rewards;
- Although it is possible to design them otherwise, most fiscal instruments only reward firms when they make profits and not when they make losses. Such instruments are pro-cyclical and offer few incentives to maintain or increase R&D investment levels throughout business cycles;
- Tax incentives are often difficult to design and can add complexity to the overall fiscal regime;
- Choosing between fiscal instruments can also be difficult. Volume-based schemes offer less incentive to raise R&D investment levels than incremental schemes, which specifically reward increases. Incremental schemes, however, are often more difficult to implement and monitor.

Experience with fiscal instruments in different national settings suggests a number of 'good practices' that should inform decisions about their use and their subsequent implementation:

- Understanding the likely uptake and demand for particular types of instrument is important. In the UK, before launching a new fiscal R&D scheme, government authorities engaged in extensive consultation with the business community. In turn, this influenced the choice of a volume-based design. This was just one part of an extensive ex-ante evaluation exercise prior to the launch of the scheme;
- There are mechanisms that make fiscal incentives less dependent on profitability, thus limiting pro-cyclical effects. Provisions such as carry-forward/carry-backward facilities and cash-refunds can be set up to make these incentives less dependent on profitability. Countries such as France, Portugal, Spain, Australia and Canada have carry-forward/carry-backward facilities, and France, UK, Canada and Australia have cash refunds in loss-making years;
- The Dutch fiscal incentive scheme (WBSO) is not based on corporate income tax but on the employer's wage tax and the social security contributions of R&D personnel. This has a very direct influence on R&D

decisions since it reduces the gross R&D salary costs on a monthly basis and frees up money for additional R&D expenditure;

- In Canada, refunds from the fiscal R&D incentive scheme are considered as income that appears in a company's profit and loss accounts. This makes the benefits of this type of scheme clearly visible at corporate CEO level and raises the general profile and importance of R&D activities within firms;
- Evaluations can lead to better practices. The Netherlands, Australia, and Canada have all performed insightful, ex-post evaluations of their fiscal incentive schemes that have led to process improvements, and the UK implemented a thorough ex-ante evaluation of its policy via theoretical analysis and in-depth consultation with the business sector.

4.2.4 Guidelines for Future Use

Fiscal incentives are recommended whenever there is a need to address a wide population of firms, including SMEs, and an associated desire to leave decisions about the content of research to the discretion of firms. If well designed and co-ordinated with other R&D policies, fiscal schemes have the potential to raise the overall level of investment in business R&D.

The fiscal incentive and tax credit schemes in place in the EU Member countries are very diverse and extremely dependent on national fiscal regimes. This rules out any recommendation concerning the adoption of a uniform system of fiscal incentives for business R&D in Europe. It does not rule out, however, **a strong recommendation that fiscal incentives are deployed as part of a policy mix aimed at raising private sector R&D levels.** Fiscal incentives clearly have the potential to stimulate business R&D, though it must be stressed that **their effectiveness is crucially dependent upon their design.** In addition, since fiscal incentives are not the only financial instruments aimed at stimulating 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**.

Recommendations concerning the design of fiscal incentives for R&D can be grouped under three headings: design issues, evaluation issues and policy mix issues.

Design Issues

There are a number of clear design principles that Member States should use to review their current fiscal mechanisms and design new ones.

- **Simplicity**. Schemes should be transparent and easily accessible to a broad spectrum of firms;
- **Low administrative and compliance costs**. For firms, it should not be complex and time consuming to apply for and receive a tax credit/allowance. For administrations, the auditing systems needed to check on the eligibility and validity of claims should be effective without being onerous for all concerned;
- **Reliability**. Firms should be able include fiscal allowances or credits in their forward plans with a fair degree of certainty. Receipt or non-receipt of tax incentives at any point in the future should not dependent on concurrent levels of profitability;
- **Stability**. The rules of the game should not be changed too often, since this reduces the ability of companies to budget for future tax benefits

when making R&D investment decisions. Greater certainty in the long term allows firms to forecast the cost of their R&D projects more accurately.

Use of these design principles has implications for the choice of appropriate fiscal incentive schemes. In terms of the choice between volume-based and incremental schemes, for example, application of these principles favours the former over the latter. **Volume-based schemes are simpler to administer for both firms and public authorities**. They are also more predictable in that firms are still eligible for benefits even if there is no growth in annual R&D expenditure. Income streams are thus less volatile and forward planning less hazardous.

Arguably, volume-based schemes are also better at raising overall R&D expenditure levels. Incremental schemes might seem to offer greater incentives for individual firms to increase R&D spending, since they specifically reward firms for doing this, but the number of firms benefiting (i.e. those increasing R&D expenditure in any one year) is invariably less than the number that would benefit from volume-based schemes (i.e. all R&D performing firms), and if these benefits – spread across the total population of R&D performing firms – are subsequently translated into increased R&D expenditure in subsequent years, the macroeconomic implication is that volume-based schemes are more likely to stimulate greater increases in R&D expenditure levels than incremental schemes.

Hybrid combinations of volume-based and incremental incentives might seem to offer the best of both worlds, but again the principles of good design outlined above suggest that such schemes add too much complexity to the overall fiscal regime and thus undermine their effectiveness.

Incremental schemes can also:

- Distort as well as stimulate R&D investment behaviour if firms allow their R&D expenditure decisions to be overly influenced by the requirements of such schemes;
- Have high compliance costs, which makes them unattractive to firms, especially to the larger firms responsible for the bulk of business R&D in most EU countries;
- Be ineffective and thus inappropriate instruments in periods of economic downturn, since incremental schemes are rarely attractive enough to firms to counter the highly pro-cyclical nature of business R&D investment decisions.

Application of the principle of **reliability** is needed to reduce pro-cyclical effects. For incentive schemes based on promised reductions in corporate income tax liabilities, this requires mechanisms capable of ensuring that tax benefits accrue from R&D investment behaviour even when profitability is low or negative. For large firms this can be dealt with via the use of carry-forward/carry-backward arrangements. For small firms, cash refunds are preferable since these have an immediate effect on cash flow.

If fiscal incentives are to have a real impact on R&D decision-making, the benefits have to be clearly **visible** to R&D and financial managers alike. This is especially important in large firms, where these functions are often quite separate and decision-making not always **transparent** to all the departments or units involved. One possibility is to consider R&D tax credits as taxable income for companies, as is the case in Canada. This makes fiscal incentives visible as an income stream in company profit and loss accounts and focuses the attention of both financial and R&D managers on the importance of both R&D and the incentive schemes associated with them. A second option is to use the Dutch model, which directly links R&D expenditure to cash flow by providing cash to firms in the year R&D is conducted.

A clear definition of R&D is needed to determine which activities count as R&D and which costs are eligible. Ideally Member States should evolve workable definitions via consultation procedures involving relevant ministries, tax authorities and the private sector, preferably informed by international standards such as those contained in the OECD's Frascati Manual. The procedures adopted in the definition and design of the UK's recently introduced R&D tax incentive schemes stand as an example of good practice in this area. As noted in Section 4.1.4, however, there is a strong argument in favour of expanded definitions of R&D if adequate support is to be given to non-technological innovation and innovation in the service sector, and the definitions used in tax incentive schemes will need to evolve accordingly.

Evaluation Issues

There is a need for **formal evaluation practices** in order to determine the effectiveness of fiscal incentives and to compare them with other types of policy instrument. These evaluations should be made publicly available for policy learning purposes. From existing evaluations there is evidence of a link between the use of fiscal incentives and the stimulation of business R&D, but current practice in the evaluation of these incentives still has three main weaknesses. First, international comparisons exploring the relative effectiveness of different types of fiscal incentive in different contexts are scarce. Ideally comparisons are needed of the use of different instruments in similar contexts and the use of similar instruments in different contexts. So far, however, evaluations of this nature have not been conducted. Second, existing methodologies are neither robust nor coherent enough to give a reliable insight into the impact of these measures in the short-, medium- and long-term. Third, many governments have chosen not to conduct external and public evaluations of their schemes, which prevents the policy community from learning of good and bad experiences with certain design models.

In order to perform competent evaluations, there is also an urgent **need for databases** containing relevant firm level information. Lack of appropriate micro-level data is probably the most important reason for the meagre number of formal evaluations of the effectiveness of fiscal incentives.

Policy Mix Issues

The task of raising R&D expenditure levels to the targeted 3% of GDP will require a mix of policy instruments. The challenge will not be met via the use of fiscal instruments alone. It will be important, therefore, to ensure that all these instruments interact positively. While direct support schemes are typically developed and implemented by ministries responsible for science, technology and innovation policy, ministries of finance usually introduce and oversee the use of fiscal instruments. Member States are thus well advised to implement adequate co-ordination mechanisms capable of ensuring consistency and coherence across the system of public support to R&D.

If the benefits accruing to firms as a consequence of fiscal R&D incentives are to translate into more R&D rather than being dissipated on other items of expenditure, e.g. increased wage levels, then governments also have to ensure that supply-side constraints on the availability of R&D personnel do not inhibit the expansion of R&D activities. In the long-term, effective education policies are needed to ensure the necessary flow of human resources, though remedying mismatches in supply and demand in the shorter-term might be more difficult without determined efforts on the mobility front to improve net inward flows of researchers.

Fiscal incentives based on **personal income tax breaks**, if appropriately formulated, can be used to attract researchers from abroad, though there is little information currently available concerning their effectiveness and impact, and suspicions abound that they may induce distortions in the EU labour market. A few EU countries, e.g. Finland, Denmark Sweden and the Netherlands, currently use this type of incentive to attract non-residents, including people from other EU Member States, though these are designed to attract a broad range of personnel and are not specifically focused on researchers. Merely encouraging the relocation of researchers within the EU, however, is unlikely to increase overall levels of R&D investment, and may even be inconsistent with the rules governing fair tax competition. To raise the total number of researchers in the EU, instruments are needed to attract researchers from outside of the EU, to retain those within it, and to maintain and expand the indigenous supply of fresh talent from EU universities.

4.3 Risk Capital Measures

4.3.1 Specificity, Potential Impact and Importance

Many of the R&D and innovation-related activities conducted by firms, especially smaller firms, are financed from external sources via equity investments or certain types of loans. Private sector R&D investment levels are thus critically linked to the well-being of the risk capital markets which provide this finance, and public policy instruments in this sphere are typically applied when these markets falter and some form of support is needed to rectify market failure. When successfully applied, these policies can therefore catalyse the flow of risk capital for R&D and innovation-related activities and lead to an overall increase in R&D investment levels, both directly via the use of this finance for R&D projects, and indirectly via the longer term reinvestment of profits into R&D activities. Before discussing the type of policies and policy instruments that can be used, however, a short description of the risk capital markets concerned and the actors involved in them is helpful.

A Short Description of Risk Capital Markets

Exhibit 4.6 summarises some of the concepts used when discussing the financing of R&D and innovation. In particular, it distinguishes between the concepts of 'Private Risk Capital' and 'Venture Capital' (VC) before going on to provide descriptions of the different uses made of 'Private Risk Capital'. In this section of the report, the broader concept of 'Risk Capital' is used rather than that of 'Venture Capital' because the latter usually refers to the provision of equity for young unquoted companies with high growth potential and high commercial uncertainty, whereas the more inclusive concept of 'Risk Capital' captures the use of loans as well as equity finance and includes hybrid equity/loan arrangements known as 'Mezzanine' finance products. The term 'Private Risk Capital' is further used to refer only to investment in companies whose shares are not traded on public equity markets.

Venture Capital is typically used to finance 'seed', 'start-up' and 'other early stage' projects. Correspondingly, 'seed capital' is finance provided at the earliest stage to research, assess and develop an initial concept; 'Start-Up Capital' is finance provided to a company for product development, initial marketing and the commencement of commercial sales; and 'Other Early-Stage Capital' is finance to an existing company with some revenues but in need of greater investment for activities such as manufacturing and sales development. The term 'Technology Investment' is also often used to describe the major focus of venture capital investment, i.e. investment in businesses likely to generate high returns via the development of new technologies or innovative uses of existing technologies.

The main actors involved in the Private Risk Capital sphere are as follows:

- The 'providers' of Private Risk Capital to companies are formal venture capital and buy-out funds as well as informal investors (i.e. business angels), corporate investors and specialist lenders using mezzanine products;
- The 'customers' of the Private Risk Capital industry are investors who are seeking risk-weighted returns from their investments. These investors are either individuals, or syndicates of individuals investing in their own right, or institutions, e.g. pension funds and banks (particularly in continental Europe);

- The 'suppliers' to the industry are the growing companies who provide the investment opportunities for the industry.

Exhibit 4.6 Private Risk Capital and Related Concepts

Heading	Sub-heading	Definition
Private Risk Capital	Seed Capital	Finance provided at the earliest stage to research, assess and develop an initial concept.
	Start-Up Capital	Finance provided to a company for product development, initial marketing and the commencement of commercial sales
	(Other) Early-Stage Capital	Finance to an existing company with some revenues but in need of greater investment for e.g. manufacturing and sales development.
	Expansion Capital	Finance for the expansion of an established, usually profitable, company
	Management Buy-Out (MBO)	Finance provided to enable an existing management team to buy a company, or division of a company, from its present owners. Usually profitable, well-established businesses.
	Management Buy-In (MBI)	As with an MBO but with new management brought in, often to turn a company around.
	Mezzanine	Finance, used mainly in larger deals in profitable companies, which combines a small amount of equity with loans secured, where possible, on the company's assets. Often used as expansion capital.
Venture Capital (a sub-set of Private Risk Capital)		Provision of equity for generally young, unquoted companies with high growth potential and high commercial uncertainty – ranges from seed to late stage investment with key feature of being 'hands-on' involvement by the finance provider. Describes the higher risk element of the Private Risk Capital industry, normally excluding MBO/MBIs and mezzanine.

The venture capital element of the industry attempts to seek out firms with high growth potential. It supports R&D-intensive companies only because these are deemed likely to grow rapidly and generate both the high returns the industry needs to compensate for failed investments and appropriate returns for investors. The main concern of the venture capital sector, therefore, is with the growth of firms as a whole rather than with the activity of R&D *per se* or, even more pertinently, with absolute levels of R&D investment. Some of the venture capital is used by firms to finance R&D, and R&D investment levels can be raised via this route, but the main purpose of the investment is to generate growth, and it is this growth that eventually allows successful companies to reinvest in future R&D activities.

Importance of Risk Capital for Private Sector R&D Spending

Although the impact of Private Risk Capital on private sector R&D spending is not the primary concern of the Risk Capital sector, there is little doubt that risk capital has a critical impact on the R&D activities of certain categories of business. Most obviously, certain R&D-intensive, independent small firms working on innovative technologies in sectors such as biosciences, ICT, healthcare, nanotechnology and new materials would not exist without risk capital financing. Indirectly too, if and when such firms succeed in solving technical bottlenecks, their activities can trigger complementary R&D spending on applications by other actors, including large corporations.

Large national and international corporations are unlikely to need private risk capital for funding R&D, as they have retained earnings and access to public equity markets. Indeed, through direct investment in promising, R&D-intensive SMEs and indirect corporate venturing (investing in venture capital funds), many large corporations are supplying funds to the private risk capital market.

The main users of risk capital for R&D are therefore young, innovation-oriented SMEs with high growth potential subject to internal financing constraints. These represent only a tiny proportion of the general population of SMEs, and only a very small percentage even of technology-oriented SMEs. To meet the requirements of risk capital investors, such SMEs need to demonstrate strong potential for rapid growth and the capacities and capabilities necessary to achieve and sustain that growth. The type of risk capital used by these companies is best described under the heading 'venture capital'.

Venture capital provided to companies in the first phases of their life cycle is often used to finance activities that are highly R&D-intensive. Consecutive financing stages and investment rounds are conventionally distinguished as seed, start-up and (other) early-stage. Broadly speaking the R&D intensity, and particularly the research component, diminishes as successive phases are completed.

Spin-off companies from universities and research institutes set up to commercialise new intellectual property are a significant and important sub-category of R&D-intensive start-ups. While some will have ambitious business plans relying on venture capital to develop, launch and distribute new products and services to international markets within a tight time scale, others with more modest ambitions will focus on contract R&D or evolve into the 'lifestyle' companies favoured by many scientists leaving full-time academic positions. Companies in the latter group are less likely to need venture capital, though a few may grow to become important venture capital candidates some years after establishment.

Factors Affecting the Flow of Private Risk Capital to R&D-Intensive Firms

Maintaining the flow of Private Risk Capital to research intensive SMEs may be important for the companies concerned and for R&D investment levels generally, but many factors affect the level and intensity of this flow. The Venture Capital sector of the industry, for example, has to compete for investors' funds with the leveraged buy-out sector of the industry. Many investors prefer to channel their funds into Management Buy-Outs (MBOs) and Management Buy-Ins (MBIs), both of which can generate returns for investors via the use of sophisticated financial leverage techniques and often do not need to generate the level of growth in individual investee companies needed by venture investors. Investors in MBOs and MBIs are therefore less likely to seek out investments that are dependent on generating growth from the research, development and marketing of new products and processes.

The flow of private Risk Capital is also greatly affected by the general financial environment and the fate of public equity markets. This is particularly true at the current time, when investment levels are at a low ebb. In December 2002, the European Private Equity and Venture Capital Association newsletter reported that

"In 2002, a large proportion of the companies funded by venture capitalists were existing portfolio companies, recapitalisations of existing businesses, or corporate divestitures. Very few new companies have been created in the last 12 months. Early stage deal flow has plummeted by anything up to 50% in the first eight months of 2002, compared to the same period in 2001."

The volume of investment recorded at the seed and start-up stage has in fact fallen from €6.7 billion in 2000, to €4.2 billion in 2001 and to €1.2 billion for the first three quarters of 2002.

Funds raised for investment also appear to have declined dramatically. According to data from the European Venture Capital Association (EVCA), a total of €10.9 billion was raised in the first 3 quarters of 2002, against a total of €38.2 billion for the whole of 2001 (with much of it raised for buy-out activity).

One significant reason for the reduction in funds raised is the impact of declining public equity market values on institutional investors. Those institutions that do invest in private risk capital often allocate a fixed proportion of their funds to this asset class. As their funds overall have declined in value (because of declining stock markets), the maximum proportionate allocations to risk capital are quickly reached, and even breached. In extreme cases, some institutions have been forced to sell (at a discount) their risk capital holdings to secondary investors and funds in order to balance their portfolios. Others have stopped making new commitments to this asset class. Those that have been forced to sell at a discount have suffered sub-optimal returns (because of the selling discounts), which makes future investment in risk capital less attractive in comparison to other asset classes.

Public equity markets affect more than just the industry's ability to fundraise however. Stock market valuations of public companies are frequently used as valuation benchmarks for risk capital investments. Lower public market valuations depress the returns that risk capital investors can expect to make from the sale of their investments (to other investment firms, trade buyers, management teams etc.). The virtual closure of public market flotations as an exit route for European high-tech venture capitalists is also a significant current problem. From a total of 249 companies floated in 2000, the flow was reduced to 47 in 2001, and 20 in the first three quarters of 2002. According to information from Credit Suisse First Boston (CSFB), only one new technology sector public offering above €30 million took place in 2002, compared to five in 2001.

Particular problems are also currently being experienced by venture capital funds seeking to raise new funds for future investment programmes. Many (but not all) of these funds lost large amounts of investors' money by investing unwisely in the 'dot.com bubble'. Even those funds that did manage their exposure to dot.com investments, and hence protected investors' returns, have become tarred by the very pervasive negative attitude that currently exists towards 'technology investing'. Some of these fund managers, even those with extensive positive track records for venture capital investing, may not be able to survive this current downturn as they will be unable to attract new institutional investment.

The Role of Public Policy

Even though the behaviour of the public equity markets has a significant effect on the risk capital industry, public policy action to stimulate these markets (beyond creating the macroeconomic stability and growth that will lead to a return of investor confidence) is not considered appropriate. Public policy action is likely to be more cost-effective and less distorting if it is targeted at behaviour earlier in the risk capital investment cycle. Whether venture capital markets are well established or undeveloped, **support measures will have most impact at the earliest stages of investment, as this is the point at which the private market is most constrained**.

The desire to implement public policies designed to increase venture capital flows and raise R&D investment levels should be tempered with caution, however. Since it is the private sector that largely drives the risk capital market, any public sector intervention creates a real danger of market distortion unless the intervention in question is sensitive and market-oriented. All recommendations for public support measures thus have to be prefaced with the general caveat that **public support should, as far as possible, be non-distorting, time-limited, non-bureaucratic and subject to robust, external, and independent evaluation**. Wherever possible, new interventions should also co-ordinate with existing regional, national and transnational risk capital measures to provide a coherent set of measures across the EU.

The public sector can influence the workings of the risk capital market by intervening in the operation of the industry whenever there is the risk of market failure. In particular, public policy instruments tackling constraints and gaps can be used: to adjust the risk-return ratios of individual investments or portfolios of investments; to address demand constraints; and to influence the framework conditions governing market activity.

Differences in regulation and taxation of investment across the EU create barriers to the efficient growth of investment in private risk capital and to the cross-border development of fund management teams. Uncertainties concerning the ownership and protection of intellectual property rights (which, at the earliest stages, are often the only asset in which to invest) can also increase the complexity and relative cost of early-stage investment. These and other framework conditions, together with recommendations for action, are discussed in greater detail in Section 4.3.2.

Constraints are recognised on the market supply of early-stage venture capital investment, particularly at seed and start-up stages. Most derive from the combination of high risk and high relative costs in relation to the investment size. Others relate to the unusual combination of business and technical skills, as well as experience, required by consistently successful early-stage venture managers. Yet another issue is insufficient networking, co-operation and co-investment among early-stage funds of different sizes and in different localities. Negative investor attitudes to venture or technology investing are also an important constraint.

There are also constraints acting on the demand for venture capital. These can arise from a lack of understanding of the needs of risk capital investors; from inadequate management; and from shortages within firms of some of the other key business resources necessary to maximise the commercial benefits of innovations. Supply and demand constraints, together with a discussion of the 'bridge mechanisms' needed to bridge the gap between the supply and demand for spin-outs from universities and research institutions, are discussed in greater detail, with specific recommendations for action, in Section 4.3.3.

Potential Impact of Risk Capital Support Measures

Understanding the potential impact of Risk Capital support measures on R&D investment levels is complicated in the first instance by the fact that the relationship between the functioning of the risk capital market and R&D spending is itself complex. SMEs as a group contribute a relatively small proportion of business R&D spending in the EU (just over 20%), and even less in the USA (just under 20%). Overall R&D intensities can be substantially higher, however, among technology-focused SMEs, particularly university and research institute spin-outs, than among technology-driven large firms. More important, though less well understood, are the leverage and perhaps catalytic effects of SME innovation activity within the whole innovation process. A key function of risk capital may be to enable the establishment of new SMEs that are permanently more R&D-intensive in their business culture than the bulk of SMEs, even more so than the class of leading technology users. Some of these SMEs will grow to be large enterprises while maintaining high R&D intensity. Small technology-based firms are also important in the competitiveness of large firms that adopt a 'buy' rather than a 'build' strategy.

In the US, the SME share of business R&D nearly doubled during the 1990s. If this is any guide, there will have to be a similar increase in the SME share in the EU if European business R&D spending is to reach the overall 3% GDP target by 2010. The annual growth rate of SME R&D spend would therefore need to be even higher than the 7% p.a. overall growth rate needed to reach the 3% target (see Section 2.1.3). Moreover, much of this growth would need to come from some of the smaller SMEs. Again the US experience may be some guide to potential, for it was the smaller firms, specifically those with less than 100 employees, that achieved by far the greatest increase in R&D spend during the 1990s, reaching a spend of $16 billion (€14 billion) annually or 10% of total business R&D by 2000. This in turn emphasises the need for the adequate provision of formal and informal venture capital.

Some measure of the maximum potential impact of risk capital support measures can be made by considering the effect on R&D spending were the intensity of seed and start-up stage formal venture investment to increase to allow the overall European average to match the current level achieved by the leading countries (at 0.1% of GDP, this comfortably exceeds that of the US). Were this increase achieved, European investment levels in seed and start-up stages would double to around €8 billion annually.

The additional SME R&D that would be generated by an increase of €4 billion in seed and start-up capital is not known and is difficult to estimate. We might assume, however, that a very high proportion (say 90%) of seed capital is utilised for R&D but that a much smaller proportion (say 25%) of start-up capital is dedicated to R&D. Given that seed capital accounts for around 12.5% of the total amount of seed and early-stage capital invested, this might suggest a crude multiplier of around 0.33 for R&D stimulated by increased seed and early-stage venture capital provision. €4 billion additional funding might therefore directly facilitate an additional €1.33 billion of SME R&D.[15]

In addition to this direct effect, there could be considerable secondary effects within the sector, not least a significant additional mobilisation of business angel investment funding seed and start-up projects that are R&D intensive. The amount of additional investment that might be stimulated is not known, but our best guess is a total of around €2-5 billion of additional R&D spend deriving from total new investment of €6-15 billion[16]. The contribution to closing the R&D gap of approximately €90 billion per year might therefore be significant[17].

Any increase in R&D spend resulting from increased venture capital provision assumes that the additional capital put in will be managed by skilled professionals and will be at least reasonably smart money, and therefore productive. Rapid increases in capital disbursements can cause the quality of investment decision-making and support to drop sharply. Poor investment decisions will lead to poor returns and hence an inability to sustain private investment in venture capital. The potential increase in R&D spending from the greater availability of venture capital is therefore large, but it will not be achieved unless commensurate investment management expertise is also available.

4.3.2 The Influence of Framework Conditions

Tax and Regulatory Environments

Risk capital funding systems are sensitive to their immediate tax and regulatory environments. Where these are complex and dynamic, barriers are created that add to the costs of creating and operating risk capital vehicles (funds). Many institutional investors are highly sensitive to costs and complexity and will divert their investments to other asset classes (public equities, fixed-interest bonds, property etc.) if the costs and complexity of investing in risk capital funds are seen as disproportionate to these other asset classes.

Much work has already been done in the EU on addressing the environment for financial services and risk capital. Specifically, the Financial Services Action Plan (FSAP) and the Risk Capital Action Plan (RCAP) have been created and are being implemented by Member States. Progress however, particularly on RCAP, has been slow and Member States would do well to revisit their implementation timetables and accelerate the pace of change in order to help address the current problems facing the private risk capital market.

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[15] N.B. All estimates assume that viable demand exists for such new investment. Viable demand comprises businesses that have genuine potential to grow and deliver returns to investors.

[16] Research in the UK (Mason and Harrison, 2000) suggests that business angels can invest up to three times as much as the formal venture capital industry in early stage investments.

[17] Research is currently underway (by EVCA) in Europe on the economic impact of venture capital. Interesting findings from the US on the impact of venture capital on innovation can be found in 'Assessing the Contribution of Venture Capital to Innovation' by Kortum and Lerner, RAND Journal of Economics, vol. 31, No: 4, pp 674-692. Amongst their findings was that $1 of venture capital produced 3 times more innovation that $1 of traditional capital

A key requirement is for risk capital investment vehicles to be tax transparent. Returns from risk capital investments are diminished when they are taxed at the level of the fund and again on distribution to investors. There is a strong case for a standardised European fund vehicle to be developed that would allow returns to flow through the fund to investors without double taxation. Such a model exists in the USA, the UK and other Member States and has recently been introduced in Belgium. Its adoption across all Member States would obviate the need for complex offshore vehicles to be established to overcome National tax rules.

The Commission should promulgate to Member States the principles of tax transparency, in line with EVCA proposals, for risk capital funds. Recent legislative change in Belgium is a useful example.

Investment by Banks

Investment by banks is an important source of finance for European venture funds. The new Basel Capital Accord, currently being negotiated, proposes risk weightings for banks allocating capital for investments in venture funds of 150%, or even 200% for start-up investments, against the current requirement of 100%. Such a change is likely to reduce dramatically the allocations that banks can make to risk capital investment, exacerbating the current problems faced by the industry and endangering its future development.

In the current negotiations with the Basel Committee, the Commission should support the EVCA argument against the proposed change in the financial regulations for venture capital investment made by banks. Co-investment by banks in venture investments should attract no more than a 100% capital weighting.

Intellectual Property Rights

Without a favourable intellectual property rights regime, other support measures for early-stage risk capital are unlikely to achieve their potential to increase R&D spend and innovation activity. Key issues here are:

- Clarification of the ownership of intellectual property developed by academics while at a university or research institute, with a strong preference for decisions to be in the hands of a single institutional controller;
- Adequate funding for the cost of protecting intellectual property through patenting, for legal costs and for professional intellectual property asset management;
- The need for EU grants and programmes to build in an option for exclusive industry licences to be granted for IPR protected products and technologies, with grant recipients obliged to nominate a single body (e.g. a technology transfer organisation) to have the rights to commercial exploitation;
- The introduction of standard revenue and royalty sharing schemes between academic institutions and the scientific institutes, departments and individual inventors within them, preferably with a high degree of convergence across Europe;
- Speedy resolution of the debate concerning the re-introduction of a minimum six months grace period while maintaining the European first-to-file regime.

State Aid and Competition

State Aid and competition rules should not unduly restrict risk capital support measures. The use of the Market Economy Investor Principle (MEIP), as a test for whether public sector investment constitutes a State Aid, has now been established. This should improve the cost-effectiveness of interventions and avoid outlawing those unable to prove their effects will always fall within R&D intensity limits.

An important issue for current consideration is the need for sensitive application by DG Competition of State Aid rules for risk capital interventions. The current risk capital market is volatile and arguably in greater need of sensitive support than it has been at other times. Strict application of bureaucratic rules could risk preventing the introduction of necessary short-term measures.

Flexibility in Public Sector Researcher Employment Contracts

Academics need to be able to become partially involved in spin-out companies – as advisers, consultants, part-time employees and shareholders – without having to give up basic employment rights or benefits within their own research laboratories. Conflicts of interest and adjustments to employment contracts should be dealt with via transparent professional and ethical codes. Obviously there are limits to this process, and some academics will cross-over to be employed by the spin-outs, but a flexible approach will still be required if links are to be maintained via their continued involvement as visiting lecturers or doctoral candidate supervisors. Academic reward systems should also look favourably on the involvement of academics in the creation of spin-offs and/or patenting and licensing activities and career progression should be affected positively rather than negatively.

Member States should build on initiatives such as those taken in France to make employment contracts for researchers in publicly funded institutes flexible enough to allow their reasonable participation in spin-out companies.

Tax Regime for Investment in Unquoted Companies

Tax relief schemes could encourage investment by taxpaying individuals in unquoted companies generally, or in R&D-intensive and innovation-oriented companies in particular if simple definitions for these can be found. One possibility involves making investment amounts deductible from taxable income. A second route involves exempting capital profits re-invested in target companies from capital gains tax. The first route achieves an alteration in the profiles for individual investors, in much the same way that public sector guarantee schemes alter the profiles for formal venture capitalists. In effect, the maximum loss to the individual is reduced by the tax saved.

Investor Protection Legislation

The European Prospectus Directive runs the risk of eliminating the very limited scope for high-net worth individuals to be treated as a separate class of the 'public' when shares in unquoted SMEs are offered for sale. Provision for a legal category of qualified or sophisticated investors, who can opt out of general investor protection provisions on the grounds of wealth and/or experience, would be very useful. Such people in the USA invest in thousands of companies that annually raise modest amounts of equity through direct public offerings, under

Securities and Exchange Commission (SEC) exemptions. Evidence from the United States suggests that 10,000 companies across all sectors could raise €10 billion annually in Europe via this capital raising route.

In transposing the Prospectus Directive, exemptions enabling Direct Public Offerings to experienced and/or risk-aware investors should be considered by Member States and implemented in a manner that maintains the necessary protection for vulnerable investors.

Quantitative regulatory ceilings across Europe on investment by institutional investors (pension funds and insurance companies) in unquoted equities (including venture funds), and in companies quoted on emerging-growth stock markets (secondary markets), gradually continue to be replaced by more flexible 'prudent-man' rules. There is little evidence that such ceilings have constrained risk capital investment in practice, but the move to proactive portfolio management (as in asset-liability modelling) needs to be maintained despite adverse equity market performance.

Interpenetration of Business and Technical Education Courses

The shortage of suitably qualified and experienced early-stage venture investors is a serious constraint on the development of the Risk Capital industry. A much wider problem, however, is the lack of business and management skills amongst people with advanced technical training, compounded more generally by a lack of empathy with entrepreneurial and business culture. This contributes to the difficulty – frequently quoted by venture managers – of building cohesive management teams for new technology-based firms. The inclusion of entrepreneurship modules within advanced technical and scientific educational courses, including coverage of venture capital and high technology start-ups, and the inclusion of technology-understanding modules in the curricula of business schools, would all help to solve these problems.

The Commission, building on the Gate2Growth programme of DG Enterprise, should encourage universities to educate all their students about entrepreneurship and the opportunities provided by 'high-technology start-ups'. Business schools should encourage their Executive MBA graduates to join R&D-intensive spin-outs and start-ups, raising the profile of such activity through funded awards and competitions across the EU. The UK Science Enterprise Challenge is a possible example here.

Networking among the European Early-stage Investor Community

There is evidence that co-investment within overall early-stage investment activity by funds of different sizes and from different locations is much less frequent in Europe than in the USA. Theoretical and practical arguments support co-investment as a way to increase the efficiency and reduce the risks of this stage of investing. Cross-border investment in Europe is hindered by the lack of a single European legal structure for venture capital funds and by the differing national tax regimes for investors, including the availability of resident and non-resident forms of tax-exempt fund.

In addition, there is a strong perception that less formal (e.g. networking) links between seed and early-stage funds across Europe are not as good as they could be. Seed fund managers are also less well trained and have lower fund management skills than their colleagues in more formal early-stage funds, and the links between venture fund managers and University Technology Transfer Offices (TTOs) are under-developed.

The Commission should support networking and training activities by organisations such as EVCA that enable greater interchange and understanding between University Technology Transfer Officers, incubator managers, seed fund managers and early stage fund managers.

The Commission and Member States should consider providing resources to support the diffusion of good practice from larger, more experienced TTOs to newer ones, complementing and building on existing initiatives.

4.3.3 Good Practice, Lessons Learned and Novel Approaches

The Range of Risk Capital Support Measures

The strength and depth of the connections between early-stage risk capital and R&D spending, as described earlier, make a *prima facie* case for public support measures that can improve the supply of risk capital and the effective demand for it from R&D-intensive SMEs (as long as these measures do not distort developing markets). Various public support measures have been targeted at relieving both supply and demand constraints in the risk capital markets. A number of 'bridge' mechanisms have also been introduced to improve the links and flows between the supply and demand sides of the risk capital industry. Exhibit 4.7 provides an overview of some of the main measures used in Europe.

Public support measures addressing supply constraints include:

- Public investment in venture funds instead of by private investors (substitution);
- Public investment alongside private investors (co-investment, to increase the funds available);
- Overhead subsidies to private investment companies (to address the disproportionate costs of making very small early stage venture investments);
- Refinancing or leverage of private investment on favourable terms (again to increase the funds available);
- Loss underwriting or risk sharing by the public sector in the risks taken by private sector investors. This can involve public investors taking the first share of any losses, or the public sector offering guarantees to compensate for losses (see Section 4.4);
- Special provision within capital gains and/or income tax rules to motivate individual (informal/business angel) investors to invest in early-stage companies.

The impact of public sector substitution or loss-sharing schemes has been seen most often in regions where venture capital activity has been largely undeveloped and a first cohort of fund managers and investors has had to be encouraged to enter the activity and gain experience. Once venture activity has been established and there is a wider range of opportunities for investors across all stages of investment, this particular approach runs an increasing risk of distorting the developing market and needs to develop via the use of more sophisticated instruments. Such variants include schemes that take a share in upside gains in order to recover some of the losses or potential losses financed or underwritten.

Exhibit 4.7 Risk Capital Support Measures: Classification and Geographical Application

Measure	European Level Schemes	Member State Schemes
Public investment in venture funds instead of private investors (100% or majority funding)		Mainly historic: 1970s, 1980s at regional level in France, Belgium, Netherlands, Portugal, Spain. 1990s in Sweden and Finland
Public investment in venture funds (or in fund of funds) alongside private investors (minority: co-investment to increase funds available)	EIB/EIF equity programmes, includes investments in funds of funds	France: National Venture Capital Promotion Fund, UK: High Technology Fund, (fund of funds level) Finland: regional venture capital fund network France: seed capital funds support programme Greece: Fund for Development of the New Economy Ireland: seed and venture capital measure Netherlands: participation companies for NTBFs Norway: seed capital funds UK: regional venture capital funds
Overhead subsidies to private investment companies	I-TEC, CREA	
Refinancing or leverage on favourable terms of private investment in high-tech companies		Germany: BTU scheme tbg and KfW variants Note: The US Small Business Investment Company programmes act to provide leverage to funds but do not necessarily focus on hi-tech.
Loss-underwriting or sharing by public sector for private sector investors		Austria, Belgium, Denmark, France Germany, Italy, Netherlands (dealt with more fully in Section 4.4)
Special provision within capital gains and/or income tax rules to provide incentives for individual (informal/business angel) investors in early stage companies		UK, Netherlands, France
Creation of regional incubator structures		Belgium, Denmark, Finland, France, Greece Ireland, Italy, Netherlands, UK

Risk capital support measures are attractive to public policy makers because of the potential for large leverage effects. In theory, 'catalytic measures' have higher potential leverage levels than those associated with the use of direct measures or fiscal deduction schemes for R&D spending. An example is where public investment is made in an early-stage fund, or in a fund investing in early-stage funds, with minimum subordination to the private investment attracted alongside it. In fact, the eventual cost to the public purse may be zero, or even negative, if the fund is successful and the subordination is not called into action to improve the returns of the private investors. Conversely, leverage can be very low if risk capital measures fail, and such failure is extremely unattractive to policymakers, especially if it leads to accusations that governments are gambling with taxpayers' money.

Support measures for risk capital are mainly implemented at national level, though there are some regional and European level interventions. Of particular importance is the activity of the European Investment Fund (EIF). The EIF invests in many early-stage funds, using its own resources and acting as agent for Commission programmes. These funds may in turn have an operational scope that is regional, national or international. The EIF also manages a programme for the Commission, providing grants to support the employment by fund management firms of new seed investment managers. The importance of the EIF in supporting venture capital activity across the EU should not be underestimated. Its remit to operate in a commercial manner also helps to ensure minimisation of market distortion.

Organisations such as technology transfer offices and incubators that 'bridge' or intermediate between research institutes/universities and the commercial and financial sectors form one important setting for risk capital support measures. As well as providing seed finance for the creation and initial structuring of new corporate entities, true 'incubators' provide physical space, business support, education and advice, networking, continuing access to research facilities and access to professional, legal and accountancy support. These organisations can act as 'bridge mechanisms' by helping to convert more research projects into potentially viable business proposals, thus increasing the quantity and quality of 'deal flow' for early-stage, formal venture investors. Public support measures for these bridge or incubator mechanisms appear crucial given that private commercial returns are unlikely ever to be earned from such activity.

Measures Addressing Gaps in the Risk Capital Market

There is evidence to support the existence of several specific gaps, problems or deficiencies in the risk capital market, all of which would benefit from the application of public policy measures:

- **The Bridge/Incubator Gap**. In essence this is the gap that exists between R&D outputs and their translation into viable business proposals. As indicated above, bridging mechanisms such as incubators are needed to bridge these two worlds;
- **The Small Seed/Early-stage Investment Gap**. This gap refers to the mismatch between the funds needed for seed/early stage projects to flourish and those actually available – a gap due in large part to the relatively small size of the amounts of capital needed by individual projects;
- **The Institutional Reluctance Gap**. This refers to the reluctance of institutional investors (e.g. pension funds and banks) to provide finance to technology venture funds, largely based on information gaps which reinforce poor perceptions of technology investing;
- **The Angel Gap**. This refers to the relative absence of finance from Business Angels in the EU in comparison with US practice;
- **The Demand Gap**. This gap refers to information deficiencies that lower the effective demand for risk capital amongst SMEs.

Alongside these specific gaps or problems is the more general notion that there is underinvestment by the private sector in early-stage venture capital because of the combination of high risk, high cost and small size of deals. In each case, experience in Europe and elsewhere proves that various public sector support measures can have some useful impact.

The Bridge/Incubator Gap

Bridging/Incubator mechanisms are relatively new in Europe. Good practice is only beginning to emerge from the wide variety of institutional and organisational formats in use, many of them experimental in nature. A basic rule is to have a clear focus on the objective, i.e. to increase the quantity and quality of the research-based deal flow available to commercial seed and/or start-up investors in a systematic, scaleable, long-term and cost-effective manner.

One of the longest running, largest and well-established bridge programmes is the locally dispersed technology incubator programme of Israel. It has well-defined parameters and rules for support and finance at both programme and project level. Its performance record in terms of cost-effectiveness and the number of new R&D-intensive companies attracting investment appears good, though there has been no independent formal evaluation and the additionality of the initiative is difficult to assess. After a review in 2001, the basic framework was retained, but with more flexibility in deal structures and more emphasis on private sector participation.

Within Europe, Finland's network of co-operating public-sector institutions, which includes SITRA, TEKES, FINNVERA and Spinno and which has more than ten years' experience supporting technology transfer and spin-offs, is a good reference point, though not enough is known about the Finnish system's overall cost effectiveness. Elsewhere, R&D granting institutes in several countries have recently (1999-2001) set aside resources for internal units supporting start-ups with services and loans. A pioneer in this area was the national FUTOUR programme established by the German government in 1997.

Another new approach (1999) is the UK University Challenge scheme, supported partly by a large scientific foundation. This is a professionally managed initiative with soft financial targets. It uses very small (typically under €5 million) seed investment funds and acts as a bridging mechanism for 15 universities. The focus of these funds, however, is more on making the financial investment than providing the necessary support and nurturing.

Fresh approaches include the German BTU Frühphasen programme administered by tbg (technologiebeteiligungsgesellschaft, a specific-purpose subsidiary of the public development bank Deutsche Ausgleichsbank). Introduced in 2001, this is an ambitious and flexible scheme that uses a network of entrepreneurial coaches and a phased grant system.

Other fresh approaches worth considering include mixed private-public sector funded large-scale pan-European technology transfer accelerators (TTAs) for broad technology themes. These would act as virtual incubators, divided into technology segments. Output, in the form of intellectual property rights, would be sold to VCs and other acquirers. The focus and concentration TTAs would bring to the activity of technology transfer, together with learning economies within sectors, would deepen technology expertise among venture capitalists and make technology transfer more commercial.

Activities at the technology-incubator/pre-seed stage aimed at converting more research projects to investment-ready business proposals should be stimulated and supported across the EU. Such activity is not necessarily profit-generating and requires some sustained public resource input to its funding mix.

The Commission should call for and fund proposals for new, co-ordinated, trans-European incubator/pre-seed fund activity. Successful proposals should include experienced, properly remunerated private management with an understanding of both technology transfer and investment processes. Proposals should be consistent with activity already existing at national and trans-national levels and should be of sufficient scale to ensure cost-effectiveness (i.e. regional or sectoral in nature).

The Small Seed/Early-stage Investment Gap

Academic research and European experience has demonstrated that there is a minimum viable size for formal venture capital funds. This size is determined both by the number of investments the funds need to achieve an effective but manageable portfolio and the need for sufficient fees to be generated by the fund to pay for the creation and ongoing management of that portfolio. Some institutions can only invest in larger funds as the administrative costs of making many small allocations to funds less than, say, €15 million is considered disproportionately high (although fund-of-funds activity can address this issue). It is also known that larger venture capital funds make larger investments. There is therefore a problem sourcing the smaller amounts of investment needed for seed, start-up and other very early stage investment projects, as all pressures on formal funds are to become larger.

One approach to this problem would be to enhance the activities of private investors by increasing the scale of their activity. In the USA, the Small Business Investment Company (SBIC) programme provides leverage of 2 or 3 times the amount raised by groups of private investors (who arrange their activities in a fund) and small institutional funds. This effectively triples or quadruples the capital available for investment by the funds. There is some evidence that this scheme allows investors a wide range of portfolio choices, including both very high-risk small seed stage investments and moderate risk investments in established technology companies. A counter-argument for such leverage or gearing programmes, however, is that they simply create larger funds that again make larger investments.

Another fresh approach to the problem of small funds targets the seed stage and brings research organisations closer to the commercial world. This is the French programme of state loans to leverage investments by public research agencies in national-sectoral and regional cross-sectoral seed funds, backed by co-investment in these funds by a specialist state-owned bank (CDC) and, *pari passu*, by private investors.

Public or private leverage to funds, while an attractive way to increase the scale of their activities, carries real risks for private investors in the equity of the funds. Where the leverage is on commercial terms, as in the US SBIC programme, any underperformance of the investment portfolio will impact most on the private equity investors, as the leverage will always need to be repaid before the private investors. Where the leverage is soft (i.e. repayment can be forgiven in whole or in part if the fund underperforms), there is a real risk of distorting of investment decisions.

There is counter-intuitive evidence from the USA that very small seed investments are being made by multi-billion dollar venture capital funds. The impact on the seed investment market by these funds is the subject of current academic research in the UK.

Public resources should be made available to provide leverage to seed funds, on an experimental basis, at both national and trans-national levels. Variants of the US SBIC model could be adopted (as in Flanders), and other measures of subsidised or commercial leverage trialled (as in France). The Commission could become involved in evaluating and reporting on the effectiveness of various forms of leverage, possibly co-ordinating with EVCA.

The EIF should consider ways of increasing its impact on the provision of finance for seed funds across the EU, both consistent with its own financial mandate and its role as a managing agent for Commission resources. This could include relaxing its 50% limit on total public-sector participation in funds in markets where private co-finance for seed funds is particularly difficult to source

The Commission should consider making resources available to accelerate research into the impact of very large venture funds on seed-level investments.

Institutional Reluctance

The reluctance of institutions such as pension funds and banks to finance technology funds is an information and perception gap. An important influence on institutional funding is historic data on the performance of venture capital funds. Compared to the data available on highly regulated and publicly-quoted asset classes, however, venture fund data is inevitably scarce, opaque and difficult to analyse. This problem is worse in Europe than in the USA, where venture performance measurement activity and its analysis by institutions is more widespread and competitive. Generally, the perception in Europe is that early-stage and technology funds have underperformed in comparison with other sections of private equity, including buy-out funds. This is not necessarily the case, however. The spread of performance is actually quite large and careful selection would undoubtedly lead to higher returns. More information, and of better quality, would lead to the wiser allocation of capital resources.

When this information gap is coupled with current negative perceptions of technology investing, held by institutions as a consequence of the bursting of the dot.com bubble, there is a real problem of institutional investment for early-stage venture funds drying up.

The Austrian Finanzierungsguarantee Gesellschaft (FGG) Capital Guarantees programme has introduced a capital guarantee programme to enable investors in venture funds to manage their potential losses and therefore overcome certain investment barriers. Other national measures include tax incentives, or public/private funds-of-funds, such as the UK High Technology Fund, the French Fonds Promotion Capital Risque (FPCR), or the Greek New Economy Development Fund (TANEO).

The EIF should play a role in providing the proper signals to the market. Given its resources, expertise, market standing, mission and longer-term horizon, it should be able to act counter-cyclically while improving, not weakening, commercial confidence. The EIF should:

- **Take the lead by committing to investment in new funds being raised by existing teams, especially those with a good recent track record who are finding it difficult to maintain institutional interest because of delays in achieving exits from their current funds;**
- **Enable venture capital fund raising teams, including those raising funds-of-funds, to attract a wider range of investors by putting flexible downside protection arrangements in place. In return for payment of a flat premium, plus a share of the upside benefits if the premium is less than risk-priced, EIF could act as capital guarantor to such investors, thus allowing them the option of adjusting their risk-reward parameters.**

The Angel Gap

Business angel finance is known to be a major source of early-stage venture capital but is poorly researched and little quantitative evidence exists concerning its impact. In the eyes of most observers and commentators, however, Europe certainly lags behind the USA in this activity. The gap between Business Angel activity in the US and Europe – the Angel Gap – has multiple aspects and causes and is probably rooted in the current immaturity of the business angel market in Europe. In the USA, the Direct Public Offering (DPO) is a well-established technique, using standard exemptions from SEC rules, which allows high net worth individuals to be approached collectively without the expense of a prospectus and Initial Public Offering (IPO). This raises their profile considerably. Adopting this process in Europe would help improve angel finance flows (see the earlier recommendation under 4.3.2 concerning investor protection legislation).

National measures such as fiscal incentives or co-investment programmes should be introduced to liberate angel market mechanisms.

Angel syndicates should be included alongside VC funds as potentially eligible for national/European tax and regulatory advantages, and for leverage schemes.

Member States should undertake national publicity measures to highlight the potential of business angel activity (as occurred in Germany). Encouragement should be given to cashed-out technology entrepreneurs and key management team members to recycle themselves as angels, mentors, coaches, VCs, serial entrepreneurs etc. National and/or regional government organisations, working with private sponsors, should fund conferences and angel networks and engage the media to raise the profile of angel investing.

The Commission should consider making funding available to and through the European Business Angel Network (EBAN) to publicise and promote angel activity via the use of success stories and role models.

The problem of availability of risk capital for the commercialisation of R&D is not just one of supply; it is also one of demand. SMEs and potential start-ups need more education and advice on the availability and appropriateness of external risk capital.

The Commission and Member States should consider making public resources available to improve awareness concerning the appropriate application of risk capital. Any such activity should complement and build on existing initiatives in the Sixth Framework Programme and elsewhere.

4.3.4 Guidelines for Future Use

The private sector risk capital market is capable of supplying large amounts of capital given sufficient deal flow within its required risk-return parameters and sufficient smart investment management capacity. Policy makers need to bear these constraints in mind and adjust risk subsidies in line with market developments to avoid negative signalling and distortion effects.

Whenever possible, allowing for the stage of development of the private investment market, risk subsidies should be minimised through competitive tendering processes amongst private sector contractors.

Support measures focusing on framework conditions for the risk capital industry may relieve bottlenecks and have higher leverage than initiatives involving financing instruments alone. Key areas to tackle include: relieving human capital constraints on early-stage, R&D-intensive, risk capital investment management capacity; intellectual property regimes affecting seed capital; and employment contracts for researchers.

Policy makers should recognise that sub-divisions and 'gaps' within the risk capital area require distinct approaches.

The Bridge/Incubator Gap

- Policymakers need to recognise an important gap in the technology transfer process between the completion of a grant-funded research project in a university or research institute and the subsequent development of a high-growth business start-up proposal that is capable of attracting outside risk capital investment on reasonable terms;
- Programmes tackling this gap should have secure financing and realistic expectations of costs and revenues. They should include adequate public or educational sector sponsorship and their continuation should not depend on generating investment returns or private sector fund-raising that can distort project selection and divert management time;
- Private sector commercial management should be used to select projects with commercial potential, taking care to broaden the selection beyond the 'low hanging fruits' that typically attract early-stage investors;
- Selected projects and teams should be supported with a very modest package of finance, mentoring and intellectual property management services for a strictly limited time-scale, with distinct milestones and the ruthless culling of those not demonstrating commercial potential.

The Small Seed/Early-stage Investment Gap

- Policymakers should encourage non-institutional sources of smart funding by piloting and evaluating leverage programmes for experienced investors – whilst recognising that these must be experimental until more is known of their actual and proportionate impact on early-stage investing;
- Policymakers should also recognise the negative as well as positive potential impact of leverage programmes;
- The role and expertise of the EIF should be recognised and drawn upon wherever possible.

The Institutional Reluctance Gap

- The production, use and understanding of better information on fund performance and manager track records needs to be encouraged;
- Measures offering downside protection to institutional investors in technology funds at market or near-market rates should be encouraged. Subsidy is unlikely to create a sustainable, long-term private investment capability.

The Angel Gap

- Profile-raising and information and awareness campaigns can have a significant positive impact on angel markets;
- Support measures should focus on mechanisms to raise capital from a class of potential investors with an appetite for high-risk/high-return investment who, through wealth and/or experience, require less investor protection than the general public.

The Demand Gap

- Supply measures alone will not improve the operation of risk capital markets. Attention also has to be paid to demand side constraints. Potential start-ups need more education and advice on the desirability and availability of external risk capital.

4.4 Guarantees for Loan or Equity Financing

4.4.1 Specificity, Potential Impact and Importance

Guarantees are financial instruments that 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. Before discussing this specific use for guarantee mechanisms, however, a short description of the major types of guarantee instrument and their broader use is warranted.

A Short Description of Loan and Equity Guarantees

Loan Guarantees

Guarantees transfer some or all of the risk of investing to a third party (the 'guarantor'). A loan guarantee is the promise of the guarantor to pay the loan if the borrower cannot or does not repay. In most cases the loan guarantee can be called if the borrower becomes insolvent. It is also possible to define other triggers.

For lenders, guarantees transfer the specified risk to the guarantors (e.g. the risk of insolvency, the risk of delayed payment, or the risk of a project failure). Lenders can therefore provide loans without taking into account these risks. For borrowers, the guarantees secure finance which would not have been possible otherwise, or which they would have received under less favourable conditions.

Furthermore, guarantors can defray potential losses if they ask for a risk-adjusted guarantee fee (also called the guarantee premium or risk premium), as in the case of guarantees offered by commercial banks. Loan guarantees provided by public institutions are normally characterised by very low or no guarantee fees. 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 (often through no fault of their own) – 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, since these are often considered to present a high or poorly understood credit risk.

Exhibit 4.8 shows the relationship between the parties involved.
Loan guarantee programmes generally include criteria defining the eligibility of different types of firm. **Horizontal** loan guarantee programmes have broad target audiences, e.g. most SMEs, or SMEs involved in manufacturing. Exhibit 4.9 gives some examples of major loan guarantee programmes, together with estimates of the proportion of all bank loans to SMEs covered by loan guarantees. **Targeted** loan guarantee programmes, in contrast, focus on smaller categories of companies, such as start-ups or innovating companies. Exhibit 4.10 provides examples of this type of programme.

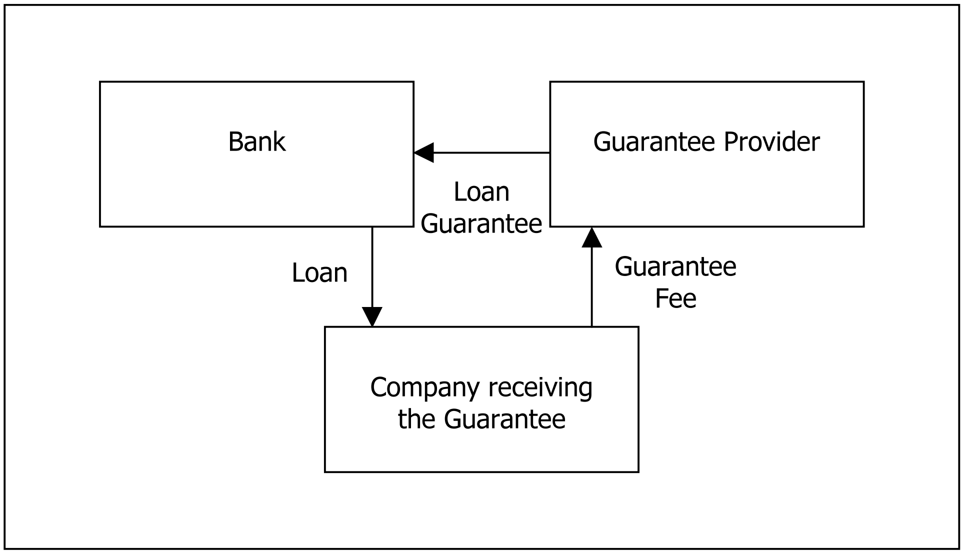


Exhibit 4.8 Loan Guarantees

Exhibit 4.9 Horizontal Loan Guarantee Programmes

Country	Major Loan Guarantee Programmes	Loan guarantees (as a % of bank loans to SMEs, late 1990s)
Austria	Small Business Credit Programme	4%
Belgium	Fonds de Participation Brussels Guarantee Fund	4%
Canada	CSBFA	n.a.
Czech Republic	Zaruka (subsidised SME Guarantees)	n.a.
Denmark	Small Enterprise Fixed Asset Guaranteed Loans	1%
Finland	Finnvera	7%
France	Creation (start-up) Guarantees SME Capital Guarantees	20%
Germany	German Credit Guarantee Association	20%
Ireland		0%
Italy	Mediocredito Centrale (MCC), National Counter-Guarantee Programme	n.a.
Netherlands	MKB Kredieten	3%
Portugal	SPGM	n.a.
Spain	Garantía Recíproca	n.a.
Sweden	Almi Företagspartner	0.5%
UK	Small Firms Loan Guarantee Scheme	Under 1%
US	Small Business Administration 7(a) Programme	8%

Note: Many countries have more loan guarantee programmes than listed.
Sources: Gracey (2001) and Bannock (1998).

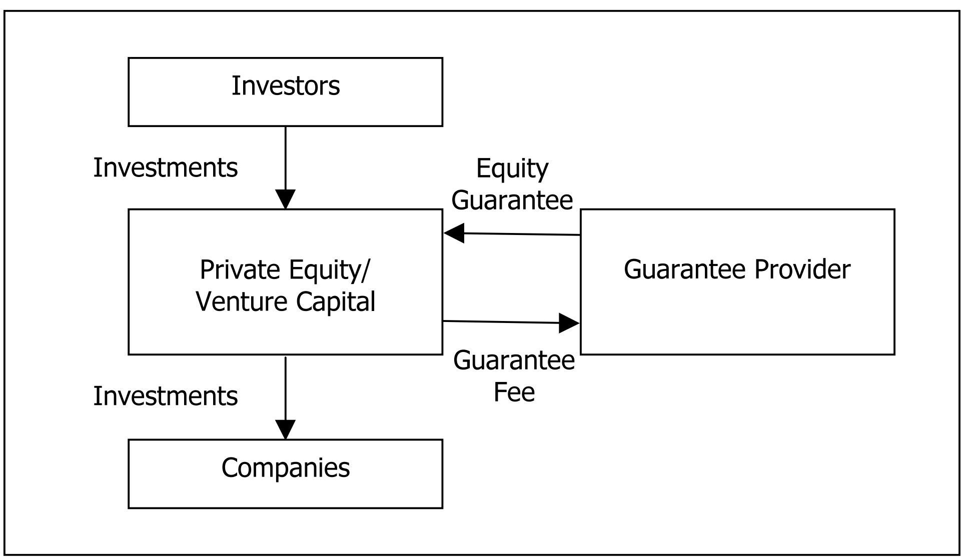
Exhibit 4.10 Innovation Loan Guarantee Programmes

Country	Scheme	Important Features
Austria	Technology Financing Programme	Combines 100% guarantee on loan with an equity guarantee
Germany	ERP Innovation Programme – Loan Variant	Combines refinancing + guarantee (repayment forgiveness in case of default)
Denmark	R&D Project Loan Guarantees	Post-default debt reduction facility + transfer of IPR to Vaekstfonden (Danish Development Fund)
Finland	Growth and Employment Guarantee Scheme	Targeted at innovative SMEs

Equity Guarantees for Specific Investments

Equity guarantees cover some of the risks of failure (loss risks) associated with equity investments. They have been developed in some European 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. As they normally cover only a part of the loss risk, they are also called 'loss sharing' guarantees. Exhibit 4.11 shows a simple equity guarantee scheme in which the guarantee is provide to the VC fund in return for a guarantee fee. Guarantees cover individual investments and are typically applied for on a case-by-case basis.

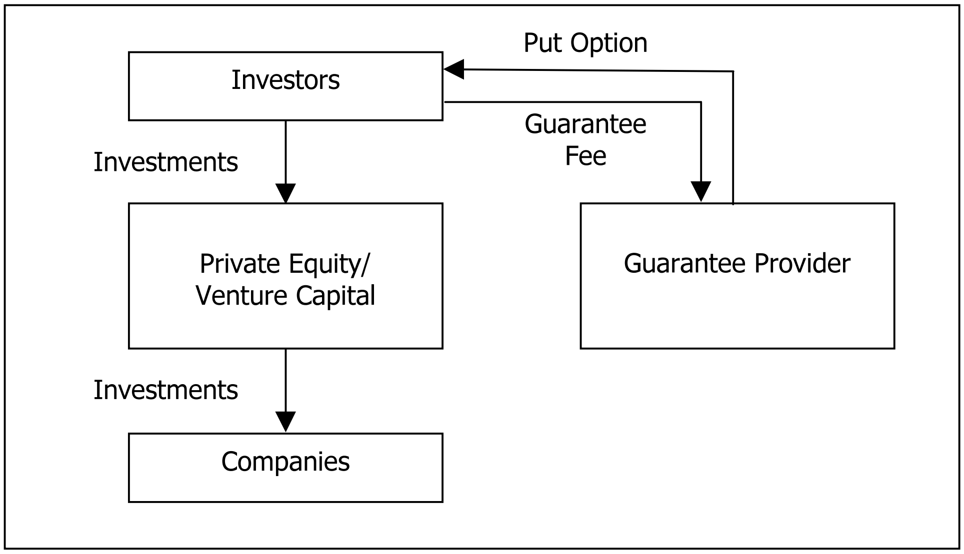
Exhibit 4.11 Equity Guarantee Scheme – Individual Investment Variant



Equity Guarantees – Portfolio Approach ('Capital Guarantees')

Another type of equity guarantee protects the capital of financial investors in VC funds. In the Austrian Capital Guarantees scheme, for example, investors in VC funds are offered guarantees to encourage them to invest in such funds. In more technical terms, the investor can buy protection against losses ('downside protection') by paying a risk-adjusted guarantee fee (see Exhibit 4.12).

Exhibit 4.12 Equity Guarantee Scheme – Portfolio Variant



In this instance, the guarantee is structured as a Put Option. This gives purchasers the right to sell an underlying asset at a specified price after a given period of time. In this case, the Put Option gives investors the right to sell their shares to the guarantor after the investment cycle of the VC funds (normally 8 to 10 years). This type of equity guarantee, which applies to portfolios rather than to individual equity investments, supports the fund-raising efforts of VC funds and enhances the availability of risk capital on capital markets (see Exhibit 4.13 for some of the design features of major Equity Guarantee Programmes).

Exhibit 4.13 Design Features of Major Equity Guarantee Programmes

Programme Name	Design Features			
	Level of Guarantee	**Own Technology Assessment**	**Provision of Co-Financing**	**Premium Charged**
SOFARIS Technology Development Fund	Portfolio	No	No	0.3% of guaranteed amount per year
FGG Capital Guarantees Scheme	Portfolio	Yes	No	Determined on a case-by-case basis
BTU – tbg Variant (until January 2003)	Individual Investment	Yes	Yes	Determined on a case-by-case basis
BTU – KfW Variant	Individual Investment	In some cases	Yes	Determined on a case-by-case basis

Counter-guarantees

Counter-guarantees are financial instruments that allow guarantee providers to share risks. The provider of the counter-guarantee accepts a specified proportion of the risk from the guarantee originator, typically receiving a portion of the guarantee fee in return. The European Investment Fund (EIF) is a major provider of counter-guarantees to national and regional guarantee programmes through the Commission's Multi-annual Programme (MAP) to support SMEs. A number of Member States also have counter-guarantee schemes for local and regional guarantee programmes. Counter-guarantees allow guarantee agencies to pool their strengths: the guarantee originator often has better knowledge of local conditions, while the counter-guarantee agency often has more financial resources.

The Importance of Guarantees for R&D Projects

As the existence of high risks is one of the main reasons for insufficient investment in R&D, guarantees can directly affect one of the most important parameters for decision-making at the company level. The primary justification for the public sector to provide guarantees is market failure in the form of lack of availability of finance for R&D projects with favourable risk/reward profiles, which leads to socially sub-optimal outcomes. Guarantees can help address this problem by altering the behaviour of overly risk-averse investors or by subsidising the costs of the establishment of investors specialised in R&D finance.

Guarantees have a number of specific features that distinguish them from other public support mechanisms for R&D. The first of these is their risk-covering nature, which can be used specifically to diminish or even completely remove R&D-related risks for investors. In contrast, other financial support instruments, such as non-repayable funds (grants) or loans with low interest rates, are typically designed to reduce the costs and raise the return on such projects.

In principle, guarantees have many potential advantages as instruments to promote R&D investment:

- Guarantees have a higher potential leverage effect than many other financial instruments, resulting in a lower burden on public expenditure for the same outcome, if realised. The leverage effects depend on the default rates of the guaranteed companies/projects and on the loss coverage rate of the guarantee fees. For horizontal loan guarantee schemes for SMEs, ratios of public expenditure to mobilised loan capital of between 1:10 and 1:20 are typical. Since other non-guaranteed funds are needed to finance projects in addition to the guaranteed loans, the ratios of public expenditure to investment can be even higher. In the limiting case of non-subsidised schemes, no additional burden results;
- This higher leverage effect can be explained by the direct influence on the risk profile of R&D projects, by the absence of marginal financing cost for public funds as long as the guarantees are not called, by the possibility of designing guarantees in an incentive-related way, and by the possibility of charging guarantee fees;
- Although many guarantee programmes are 'horizontal', they can also be directed at specific targets by defining narrower eligibility criteria;
- Guarantees can foster 'public-private' partnerships by structuring the sharing of risk between investors and public guarantee agencies;
- Guarantees can help overcome some of the regulatory constraints on investors that constrain the flow of finance to R&D. For example, some pension funds and insurance companies are currently prohibited from investing in venture capital funds in the absence of guarantees, whereas

they would be allowed to invest in them if the guarantees were in place. Guarantees can also mitigate some of the potentially negative effects of the 'Basel II' regulations on bank capital. These regulations, proposed by bank regulatory agencies under the auspices of the Bank for International Settlements, may make it more difficult for SMEs to get bank loans without a guarantee;
- Guarantee fees offer a way around some of the additionality problems associated with public subsidies (so-called 'deadweight losses'). Whereas grants or loans with soft conditions can attract R&D performers who would have undertaken projects even in the absence of support, the obligation to pay a fee helps deter applications for guarantees unless they are really needed to finance projects. There is in fact some evidence that guarantees (along with other 'self-selecting mechanisms' such as royalty-sharing grants) are more effective at reducing 'deadweight' than general measures such as tax credits (Fölster, 1991). Their effectiveness, however, is likely to be maximised if they are employed in conjunction with measures such as those proposed in Section 4.3 of this report, which aim to improve the environment for early-stage venture capital (particularly seed capital)

At the same time, guarantees have a number of potential drawbacks. This means that guarantee programmes must be carefully designed and implemented in order to minimise these problems. Potential drawbacks include:

- Adverse publicity, for although potential leverage is high, isolated failures and the premature calling of guarantees – which can happen in downturns – can attract adverse comment and accusations of misuse of public funds;
- The difficulty of estimating the ultimate costs of guarantee programmes to public budgets. One mechanism for limiting costs, however, is to place a cap on the maximum potential liability of schemes;
- Moral hazard on the part of investors and/or firms, with both taking advantage of the reduction of risk offered by guarantees to undertake R&D investment strategies with even higher risk/reward ratios. One way of dealing with this problem is to limit the guarantees to less than 100% of the total investment (e.g. 50% or 80%). In this way investors still have 'money at risk' and an incentive to select and monitor their investments carefully;
- The costliness of risk assessment, particularly for technology-related investments. Some guarantee agencies have introduced standardised rating or credit scoring systems based on a limited number of variables to help speed up and reduce the cost of risk assessment;
- Particularly for smaller guarantee schemes, which design guarantees on a case-by-case basis for specialised purposes, there is considerable complexity involved in structuring acceptable deals and many difficulties associated with monitoring their progress. Furthermore, there are legitimate concerns about the transparency of complex guarantee structures;
- The potential for market distortion is ever present unless great care is taken in the design of programmes;
- Although guarantees can reduce deadweight, they are generally more expensive to administer than schemes such as tax credits.

Target Audiences

When addressing the issue of target audiences, it is useful to distinguish between different categories of firm along two dimensions: the size/age of the firm; and the research intensity/innovation potential of the firm (see Exhibit 4.14).

Exhibit 4.14 Typology of Target Audiences

		Research Intensity/Innovation Potential		
		R&D intensive	*Innovative*	*Potentially Innovative*
Size/Age of Firm	*Seed/Start-up/ Other Early Stage Projects*	(1) NTBFs	(2) Innovative Start-ups	(3) Low-tech Start-ups
	Established SMEs	(4) High-tech SMEs	(5) Innovative SMEs	(6) Low-tech SMEs
	Large Firms	(7) High-tech Large Firms	(8) Innovative Large Firms	(9) Low-tech Large Firms

In terms of the size/age of firm, seed/start-up projects are considered the most risky from an investment point of view. These types of firm frequently lack adequate internal financial capital and experienced management. Various studies in different countries have estimated the 'mortality rate' of start-ups to lie between 25 – 50% in the first few years of existence (Deutsch, 2001). External investors also have difficulties estimating risks and selecting promising investments, in large part due to the lack of any financial track records for the firms upon which investment decisions can be made.

The risks of investing in established SMEs and large firms are much lower due to the lower mortality rate of firms in these categories. Investors also feel that it is easier to assess investment risks for these types of firm. Banks in particular look at the track records of firms (e.g. profitability, sales growth, etc.) and treat tangible assets (e.g. real estate, plant and equipment, etc.) as security for loans, which they can seize and sell to cover part of their losses in case of default on the loans. With the help of these mechanisms, banks in countries such as Germany and Italy experience default rates as low as 1 – 2 percentage points for these types of firm.

Along the research intensity/innovation potential dimension of Exhibit 4.14, R&D intensive firms and projects are the most difficult for external investors to evaluate, since many investors lack the specialised technical know-how to make these judgements and to estimate the potential returns from R&D projects. For this reason, investors such as banks tend to avoid lending to this type of firm. Interestingly, some studies suggest that technology start-ups may not in fact be more risky than low-tech start-ups, despite the widespread belief to the contrary (Storey and Tether, 1998).

The risks associated with firms in categories (1) and (2) (NTBFs and innovative start-ups respectively) are thus considered high on two counts, first because of their size and fledgling status, and second because of their high R&D intensity. Firms in categories (4) and (5) (High-tech SMEs and innovative SMEs respectively) also face difficulties obtaining external finance due to the aversion of many investors to firms heavily involved in high risk R&D activities.

The typology of firms presented above is useful when specifying appropriate target audiences for different types of guarantee mechanisms, in particular equity versus loan guarantees:

Equity Guarantees

- Due to the high investment risks associated with R&D-intensive and innovative seed projects and start-ups (categories 1 and 2), equity investments rather than bank loans are more appropriate forms of external investment. Equity guarantees are thus the appropriate mechanism to stimulate increases in R&D activity amongst these firms;
- Due to the specific demands of this type of investment, equity guarantees should be aimed at financial intermediaries specialising in this kind of investment, such as VC firms and business angels. R&D-intensive firms are thus indirect beneficiaries, since the direct beneficiary of the guarantee is the financial intermediary;
- The benefit of this instrument is likely to be greatest in those countries and regions where there is not yet an established venture capital industry. Equity guarantees can contribute to the development of such an industry by helping new VC initiatives to raise funds. Furthermore, they can limit the downside risk of individual investments during the long period of time it takes to develop a mature VC industry. This development can be quite costly, however, due to the need to develop a supporting network of technology, legal and other specialists, and due to the extended learning period needed for VC investment managers.

Loan Guarantees

- Loan guarantees are more appropriate when there is a need to stimulate finance for established SMEs to conduct R&D projects with a limited risk profile (categories 4 and 5). These 'actively innovating' companies account for perhaps 15% of the SME population in Europe. The investing risks here are less than those involved in NTBF and innovative start-up finance for two reasons. First, the established SME typically has a much stronger financial basis, such as a higher level of equity and more cash on hand, and thus the failure of a project is less likely to endanger the survival of the firm as a whole. Second, the types of R&D projects undertaken by these firms, such as incremental improvements in existing (and already successful) products, are frequently less risky than those of NTBFs. For these reasons it is more appropriate to use bank loans as external finance than it is for start-ups;
- The impact of loan guarantees is likely to be greatest in countries and regions where banks are highly risk averse, i.e. where they are reluctant or unwilling to lend due to lack of sufficient collateral or the nature of the investment project;
- Most loan guarantee programmes are 'horizontal' in the sense that a broad spectrum of SMEs is eligible. The typical primary goal of these programmes is job creation or the promotion of new firms. The specific impact of horizontal programmes on R&D spending is likely to be very small, with significantly less than 10% of the guaranteed amount going into R&D spending. Horizontal loan guarantee programmes are thus not the most efficient instruments to promote R&D spending in Europe;
- Guarantee programmes (or financial programmes with a guarantee component) that are targeted specifically at loans for R&D and innovation occur less frequently in Europe. This targeting can be done in either of two ways. One way is to limit eligibility to R&D intensive firms or innovation projects. Another way is to create special provisions within horizontal loan guarantee programmes, either by more generous risk criteria for R&D-intensive companies, or by defining an additional guarantee trigger such as the failure of the R&D project. Such a guarantee would be economically equivalent to a conditional grant, if the guarantor takes over the repayment of the guaranteed loan without any

reimbursement from the borrower. A key design issue for such programmes is the way in which R&D risk is assessed. In particular, specialised technology risk assessment units within banks or guarantors can help improve the selection of appropriate investments. Programmes of this nature are likely to have a greater impact on R&D spending than horizontal programmes;

- In principle, loan guarantees could also encourage the external financing of low-risk R&D projects within larger companies. The take-up, however, would probably be less since these types of companies tend to be less cash constrained than SMEs.

Potential Impact of Guarantees

The immediate quantitative impact of the establishment of new guarantee schemes and a rise in activity of existing guarantee schemes is likely to be small in absolute terms.

The main target audience, SMEs, accounts for a modest but nevertheless significant proportion of R&D in both the EU and the benchmark case, the US (somewhat less than 20% of total R&D in the latter). This SME intensity varies widely between countries and regions in Europe, as does the presence and take-up of equity and loan guarantee programmes. For example, whereas about 20% of bank loans to SMEs in Germany and France are covered by loan guarantees, loan guarantee programmes in the UK are involved in less than 1% of total SME lending.

The uptake of equity guarantee programmes has been much higher in some European Countries. The German BTU (Beteiligungskapital für kleine Technologieunternehmen) programme, which involves both a financing and a guarantee component, has been used by the majority of NTBF-oriented Venture Capital Funds. Similar high demand has been reported in France and in Austria. In the latter case, 60% of all Venture-backed start-up and early stage investment projects in the year 2000 had been financed by Venture Capital funds in connection with Equity Guarantee Programmes. The impact of Equity Guarantees on the availability of risk capital for R&D projects of SMEs is thus potentially high, at least in the short term. Longer-term sustainable impacts are more difficult to achieve and very dependent on general market conditions, as demonstrated by the decrease in Venture Capital investments in the years 2001 and 2002.

Estimating the potential impact on R&D investment of an increase in guarantees in Europe is complicated by the relative dearth of any detailed evaluation studies of existing guarantee programmes. It is nevertheless safe to say that the impact of an expansion in horizontal loan guarantee programmes on R&D investment would be small due to the low 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 programme could help reduce the R&D investment gap relative to the US amongst NTBFs and established SMEs. As noted earlier in Section 4.3, measures supporting the development of venture capital in Europe could help boost R&D investment by over €1 billion directly and a further €2 – 5 billion indirectly, a small but significant proportion of the overall €90 billion gap relative to the US. Guarantee mechanisms could be a key instrument contributing to this increase.

4.4.2 The Influence of Framework Conditions

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.

State Aid Regulations

Guidelines developed by the European Commission on State Aid have a direct impact on the specificity, pricing and other characteristics of public guarantee programmes:

- The 'Commission Notice on the application of Articles 87 and 88 of the EC Treaty to State Aid in the form of guarantees' (European Commission, 2000) outlines the Commission's general stance on public guarantees. This notice suggests that guarantee coverage of no more than 80% of the total financial operation is appropriate in order to leave an incentive for lenders to monitor borrowers. The notice also states that guarantee schemes that are not self-sustaining (i.e. where income premium from guarantees does not cover the costs of default, administration, and the normal return on capital) are considered as forms of State Aid which thus have to be submitted to the Commission for approval;
- The Commission communication on State Aid and Risk Capital (European Commission, 2001b) asserts that public schemes to encourage the development of risk capital are justified if they help address market failures blocking access to finance for SMEs and new firms. These failures can be due, for example, to imperfect or asymmetric information, or to high relative transactions costs.

The current State Aid guidelines on guarantees are not a major impediment to the design of appropriate programmes. Of more concern are the restrictive guidelines on R&D support, since these are largely based on the 'linear' model of R&D. These are relatively generous in allowing the use of subsidised guarantees to support R&D, but put much greater constraints on the commercialisation of the results of R&D projects.

Financial System

Financial system regulations help shape the incentives for investment, which guarantees in turn try to influence. One very important example concerns prudential regulations, which can act to prevent investors, e.g. pension funds and insurance companies, from investing in riskier vehicles such as venture capital without a guarantee. Another example concerns the Basel II agreements on bank capital adequacy, which have the effect of (amongst other things) reducing the incentives for banks to invest in SMEs. In the latter case, guarantees can help reduce the capital banks need to set aside for SME loans, thus reducing some of these disincentives.

The level of development of the financial system and the practices and attitudes of its main actors also moderate the effectiveness of guarantee schemes. For equity guarantees in particular, the presence or absence of venture capital and an active market for high-tech Initial Public Offerings (IPOs, i.e. new listings of companies on stock exchanges) can have a decisive impact. For loan guarantees, the varying requirements of banks for collateral and their procedures for evaluating the suitability of firms for loans can also have a critical influence on the success of loan guarantee schemes.

Macroeconomic Policy

A highly cyclical fluctuation in the orientation towards risk is a fundamental feature of financial systems. This particularly affects the riskier types of investment vehicles: in the famous words of one observer of Wall Street, equity investors fluctuate between fear and greed. Macroeconomic policy has a dual effect on this orientation, firstly through the monetary transmission mechanism (which directly affects liquidity and the 'taste' for higher-risk assets) and, secondly, through its influence on the general level of demand (and thus the 'opportunities' for new, high risk products), the size of investment budgets for new technologies, and the amount of consumers' discretionary spending. A growth- and stability-oriented macroeconomic policy is thus a very important positive framework condition for the supply of finance for R&D investment and the demand for R&D-intensive goods and services.

Climate toward Entrepreneurship and Innovation and the Stock of Entrepreneurial Skills

Constraints on R&D can exist on both the supply and demand side. In the case of guarantees, even well-designed and funded guarantee schemes can have a low take-up in the absence of, on the supply side, an adequate supply of ideas for R&D projects, sufficient entrepreneurial initiative, and the skilled researchers needed to carry out the work. On the demand side, critical ingredients are investors with risk orientations compatible with the risk profiles of the R&D projects proposed and the skilled personnel (investment managers, lending officers/relationship managers, etc.) needed to evaluate and monitor these investments. All these supply and demand constraints are functions of general cultural factors, the entrepreneurial orientation of the region/country involved, the quality and orientation of educational institutions (including higher education establishments), and the opportunities for on-the-job acquisition of relevant skills and experience.

4.4.3 Good Practice, Lessons Learned and Novel Approaches

Many good practices and novel approaches can be found in European equity and loan guarantee schemes. These provide a wealth of experience that can be drawn upon when modifying existing programmes and introducing new ones.

Equity guarantee programmes have been introduced more recently than loan guarantee programmes, and most have not yet been evaluated. Some of these programmes have experienced high losses since the technology bubble burst, and many have been subject to the criticism that they were not selective enough in their coverage. Nevertheless, a well-designed equity guarantee programme can, in principle, contribute to the development of a local venture capital industry. Equity guarantee schemes of particular interest include:

- The SOFARIS Technology Development Fund (France), which guarantees portfolios of equity investments by financial intermediaries (mainly VCs). It maximises leverage by focusing on intermediaries with successful track records, while at the same time minimises administration costs by relying on these intermediaries to assess risks and monitor portfolios;
- The Finanzierungsguarantee Gesellschaft (FGG) Capital Guarantees scheme (Austria), which supports fundraising by new or relatively new venture capital firms by guaranteeing portfolios of equity investments. It also reduces the risk for investors of investing in new VCs by controlling

risk exposure through corporate and technology risk assessment by an experienced in-house team;

- The BTU (Beteiligungskapital für kleine Technologieunternehmen) programme (Germany) is aimed at the development of a viable venture capital industry, while at the same time increasing the supply of funds available to this industry by providing both guarantees and financing. One part of this programme, which operates through the tbg (technologiebeteiligungsgesellschaft, a specific-purpose subsidiary of the public development bank Deutsche Ausgleichsbank) provides co-investment (up to 50% of the total investment, with the remainder provided by the private sector) and, until January 2003, guaranteed up to 50% of the private sector's investment in NTBFs. A second part of this programme, operating through the Kreditanstalt für Wiederaufbau (Kfw, another public development bank) refinanced up to 70% of financial intermediaries' investments in NTBFs (50% as of January 2003) and provides a guarantee on this portion of the investment.

In terms of loan guarantee schemes, examples of good practice and new approaches include:

- The UK Small Business Loan Guarantee Scheme, in existence since 1981, is a prime example of a cost-effective horizontal loan guarantee scheme. An evaluation of the scheme in 1999 estimated that 70% of the SMEs benefiting from the scheme would not have been able to receive a loan, or would have received a smaller loan, in the absence of the guarantee. High-tech SMEs are not specifically covered, and the scheme is unlikely to have had much impact on R&D spending. Nevertheless, such programmes can improve general levels of innovation, for 53% of the firms stated that they were using the loan to finance new products or services;
- Although the Finnvera loan guarantee scheme (Finland) is also horizontal (i.e. it is available to a broad spectrum of SMEs), it is estimated that 5-7% of the companies benefiting from the scheme are technology-related. The strength of the scheme is a rigorous, but low cost, corporate and technology risk assessment system, which helps identify R&D investments with a low probability of failure. Approval of a guarantee by Finnvera is often accepted by banks, who are not able to perform such comprehensive risk analyses, as a positive signal for investment;
- The Kreditanstalt für Wiederaufbau's ERP (European Reconstruction Programme) innovation loan programme (Germany) involves both a refinancing and guarantee component for banks investing in innovation projects (including R&D projects) in established SMEs. Although these are relatively low risk projects, and the future earning power of the firms involved is sufficient to repay the loans in the case of project failure, many banks are nevertheless unwilling to provide finance for this type of project without a guarantee;
- The Finanzierungsguarantee Gesellschaft (FGG) Technology Financing Programme (TFP) (Austria) offers a combination of equity and loan guarantees for technology-oriented SMEs. Costs covered by the scheme include R&D, technology investment, and education and training costs. A 100% guarantee is provided for the bank loan component of financing, which in turn leverages the equity financing component, itself typically provided by venture capital funds. Risk is controlled by conducting in-house risk appraisals and by maintaining incentives (a 50% equity guarantee) for equity investors to appraise and monitor the investments.

Experience in these programmes supports a number of general principles:

- Although public guarantees should reduce the risk exposure of private sector investors, this risk should not be completely eliminated. Risk-sharing ensures that private investors still have an incentive for projects to be successful;
- Decision-making on guarantees should be speedy, in part due to the rapidity of technological innovation;
- Programme requirements and features should be simple, so that users can understand programmes and their logic quickly.

A number of new approaches in the area of guarantees deserve consideration and promotion. These include:

- **Option-based approaches to the assessment of risk and pricing guarantees for R&D investments**. Due to the unique nature of R&D investment, including high uncertainty and the binary nature of returns (failure or success), traditional investment models such as the discounted cash flow (DCF) model lead to under-investment in R&D. Traditional cash-flow based investment calculation models do not adequately reflect the value of R&D projects as a chance (an option) to capture future cash flows. Due to the costs of calculating these values on a case-by-case basis, however, option-based approaches are most appropriate for guarantee schemes which provide a small number of larger guarantees, e.g. portfolio guarantees intended to support the fund-raising activities of venture capitalists;
- **Securitisation of SME loan portfolios**, some of which involve R&D projects. Securitisation involves the bundling together of a large number of assets of a single type (such as real estate mortgages) and the sale of rights to the capital and income from this portfolio in the form of financial securities to investors. Securitisation here is driven by the desire of banks to free up regulatory capital for new loan commitments. Securitisation helps maintain the flow of funds to SMEs at a time when developments like the Basel capital adequacy agreements appear to make it more difficult for many banks to lend to portions of this market segment. At a national level, Germany's Kreditanstalt für Wiederaufbau has gained significant experience in securitising SME loan portfolios. Some of these transactions have been supported at European level by the European Investment Fund, which has a mandate from the European Commission to support finance for SMEs. The KfW is currently considering putting together a securitised loan pool for renewable energy projects, some proportion of which will be R&D intensive investments;
- **Technology rating systems**. Private sector financing of risky projects on a widespread basis requires some mechanism to quantify these risks. Traditionally, standardised risk assessment systems have focused on financial indicators such as debt/equity ratios, cash flow/asset ratios, etc. The reluctance of investors to provide finance for R&D projects derives in part from the difficulty of estimating or rating the risk of these projects, each of which has unique characteristics. Nevertheless, some innovative agencies and investors, such as Finland's Finnvera, have successfully developed economical ways of estimating technology-related risks, thus reducing the barriers to obtaining external finance for R&D projects. Guarantee institutions could help to create a market for rating services by requiring applicants to submit company or project ratings as precondition for dealing with applications;
- **Including guarantees in packages of support and services**. The support of R&D-intensive companies often involves more than one public instrument and more than one public agency. However, multiple (and different) applications and lengthy decision-making times can

substantially reduce the attractiveness and effectiveness of public instruments. One fresh approach has been taken by Italy's Mediocredito Centrale (MCC), a private sector bank with a contract with the government to run the national counter- and co-guarantee schemes. Guarantees are offered as part of a larger package of support and services, which can include grants, advisory services, and loans. This packaged approach requires only one application, and the provision of support and services is coordinated over time;

- **Innovative insurance approaches to R&D finance**. Guarantees are essentially a special form of insurance. In principle, therefore, insurance companies should at least be interested in ways of insuring against the risk of R&D projects failing. In practice there has been some discussion of pharmaceutical and biotech companies insuring against the failure of clinical trials, but no known implementations. One insurance company (Swiss Re), however, has been involved in organising the Princess Bond, a special instrument which allows private investors to benefit from the upside potential of participating in a portfolio of venture capital funds, while at the same time insuring against the downside risks. This private sector instrument, which helps raise funds for venture capital, is interesting in theory it that it might eventually reduce the need for public sector guarantees.

4.4.4 Guidelines for Future Use

Evaluation of Guarantee Schemes and Exchange of Good Practice

There are few evaluation studies of guarantee programmes, and even fewer that focus on the relationship between the use of guarantees and R&D investment levels. This makes it very difficult to judge whether or not they have been successful, and even more difficult to make predictions about probable impacts. More and better evaluations are needed if programme design and performance are to be improved. Greater exchange of information on particular aspects of programme design, operation and performance, e.g. on the use alternative methods of risk assessment procedures, would also improve practices across the EU.

Member States should therefore improve their practices with regard to the evaluation of guarantee programmes. Impact on R&D investment levels should also be included as one of the criteria for judging the success of equity and innovation loan guarantee schemes.

Furthermore, learning structures for diffusing the results of good practice and for assessing the impact of guarantee schemes on R&D spending should be created. The EIF is already involved in this area and could potentially increase its role significantly.

Equity Guarantees

Equity guarantee programmes have already been tried in a number of Member States and have successfully contributed to the entry of new venture capital firms and the establishment of a viable early stage venture capital industry. This is important for promoting R&D spending, since VCs are one of the main sources of external finance for NTBFs.

EU Member States without a developed venture capital industry, particularly those without 'early stage' venture capital firms focusing

on the provision of seed and start-up capital, should consider introducing an equity guarantee programme.

Existing and previous programmes provide many lessons for the design of new initiatives. One guiding principle is that subsidised equity guarantee programmes should only be offered until self-sustaining venture capital sectors have been established, since the rationale for such programmes is reduced once the self-sustaining stage has been reached. For seed stage and very early stage developments, however, it can be argued that permanent market failures necessitate a longer-term role for subsidy schemes. A second guiding principle is that the use of option-based models in the pricing of guarantee premiums is warranted, since these models avoid many of the problems associated with the widely used discounted cash flow model and historically-based hazard models. However, there are no clear guidelines for assessing the risks accompanying technological development. In some programmes, a key feature of programme design is that the guarantor performs the technology risk assessment, while other programmes rely on incentive mechanisms that motivate investors to carry out the risk assessments.

The EIF could help support these new equity guarantee programmes by providing counter-guarantees to them. Providers of counter-guarantees share risks with guarantee agencies by accepting a specified proportion of guarantee risk for a fee. The EIF has successfully promoted the development of loan guarantee programmes in a number of Member States by offering counter guarantees, and this experience could be usefully duplicated for equity guarantees. The EIF is ideally positioned for such a counter-guarantee programme because of its unique experience as a European Fund-of-Funds investor, that is, as an investor in many venture capital funds. Based on its existing loan counter-guarantee programmes, it is also knowledgeable about many national guarantee institutions and programmes. The EIF's provision of counter-guarantees is currently carried out on behalf of the European Commission and is regulated under the Multi-Annual Programme (MAP) to support SMEs. Current regulations and the European Commission mandate to the EIF should be examined and, if necessary, modified to allow the EIF to provide equity counter-guarantees to national and regional guarantee agencies.

Loan Guarantees

The basic rationale for loan guarantees is to improve the supply of external finance to SMEs by overcoming market failure in credit rationing.

Horizontal loan guarantee schemes, i.e. schemes applicable to a broad spectrum of SMEs, are more appropriate for achieving goals such as job creation than for the promotion of R&D spending. One reason for this is that the proportion of R&D intensive firms benefiting from this type of scheme is small. Thus the impact of an increase in the size of these programmes on R&D investment will also be small. A second reason is that most banks are not equipped to judge the risks of R&D investment. However, Member States such as Germany and Austria have had some success with innovation loan guarantee programmes, or programmes with a loan guarantee component, which are specifically targeted at the financing of R&D projects in established SMEs. These programmes include mechanisms for the evaluation of technology risk. Support for these projects is less risky than financing start-ups because established SMEs tend to have enough resources to absorb losses from failed projects. Furthermore, R&D projects undertaken by established SMEs are typically incremental improvements of existing products and services that involve lower levels of risk. **Member States without a targeted innovation loan**

guarantee scheme should thus consider the establishment of such a programme. Alternatively, Member States with existing horizontal guarantee programmes should consider introducing special provisions for R&D-related investments. This could be done either by introducing more generous risk criteria for R&D-intensive companies or by defining an additional guarantee trigger such as the failure of the R&D project.

The EIF should support developments such as these by providing counter-guarantees for new national and regional innovation loan guarantee programmes, or for horizontal programmes with special provisions for R&D-related investments. The EIF is already involved in the provision of counter-guarantees to horizontal loan guarantee programmes under a mandate from the European Commission's Multi-annual Programme. Current regulations and the Commission's mandate to the EIF should be examined and, if necessary, modified to allow the EIF to provide counter-guarantees specifically for innovation loan guarantees.

Innovative Financial Practices

The flow of finance to innovating SMEs, and perhaps to larger firms as well, could be usefully stimulated via the broader use of innovative financial practices and products. One possibility is the **securitisation of SME loan pools**, which typically include some loans for R&D and innovation, and which have already been repeatedly used in Germany. The experience to date with loan pool securitisation should thus be examined with an eye to the expanded use of securitisation at a national level and, backed by the EIF, at European level. **Member States should then consider broadening the remit of existing agencies or development banks to include loan securitisation.**

The EIF could support this development by participating in securitisation, as it has done already in a number of EU countries. The European Commission should establish a mandate for the EIF and provide the necessary financing to manage a new facility specifically for loan securitisation.

As part of the securitisation initiative, the possibility of creating a pan-European market for the rating (including technology rating) of SMEs should be considered. Inasmuch as this would help public guarantee institutions to assess risks, public agencies should consider bearing at least a portion of the costs of such a scheme, which can be high relative to the resources of SMEs.

A second product, which has not yet been widely used but which in principle could support R&D finance, is an insurance product that would insure companies against the risk of failure of R&D projects. Since this is a product primarily offered by the private sector, **the European Commission can best support it by monitoring its use in other countries and by encouraging a discussion of its merits.**

5.0 Combining Policies

The point was made in Section 2 that the complexity of innovation systems implies that multiple policy instruments are needed to maintain and nurture them, and that appropriate policy mixes include instruments which tackle both framework conditions, as discussed in Section 3, and more focused financial and fiscal instruments of the types discussed in Section 4. The very complexity of innovation systems, however, is also one of the factors underpinning their diversity and leads to the observation that no one innovation system, whether defined at regional, national or international level, is exactly the same as another. Unfortunately, the natural corollary is that appropriate policy mixes also differ on a case-by-case basis – a situation reinforced by the fact that the historical evolution of science, technology and innovation governance structures and policy delivery mechanisms also plays a part in determining the appropriateness of a given policy mix.

While it is certainly true, therefore, to conclude that policy mixes that work in one setting cannot and should not be transferred wholesale to different settings, this does not mean that useful lessons concerning the appropriateness of particular policy mixes cannot be gleaned by consideration of their efficacy in other settings. Neither does it mean that the process of policymaking cannot benefit from the use of simple analytical guidelines, nor that governance structures and procedures cannot be improved via comparison with structures and procedures elsewhere. In the remainder of this section, therefore, some of the policy mixes used around the world are compared and contrasted and the potential of different combinations designed to increase R&D investment levels explored. Guidelines concerning ways of tackling the problem in different settings are also discussed and commentary offered on issues of delivery, coordination and governance of particular relevance to the raising of R&D investment levels.

5.1 National Policy Combinations

The range of policy mixes in operation around the world is evident from Exhibit 5.1, which is based on a review of technology policy instruments undertaken by Technopolis B.V. on behalf of the Dutch Ministry of Economic Affairs. It focuses on national policy mixes in support of industry-oriented R&D and innovation and maps specific policy objectives against five main policy delivery mechanisms.

The first point to note is that the policy mixes employed do vary considerably from one context to another. Support for R&D projects in single firms, perhaps the most conventional focus of science, technology and innovation policies over the last thirty years or so, remains the most common policy objective in all countries, though the delivery mechanisms vary. Tax-related measures are the most popular way of delivering this form of support in six of the seven countries surveyed, though shares in the total innovation budget range from a high of 87% in New Zealand to 25% in the USA and the absence of any R&D-related tax measures in Finland. The dominance of this delivery mechanism in the UK is also a very recent phenomenon.

Exhibit 5.1 National Policy Mixes in Support of Industry-oriented R&D and Innovation

(Percentage of Total Innovation Budget)

	Support for R&D in single firms	Support for R&D co-operation	Measures addressing the mismatches in (risk) capital markets	Improving absorptive capacity	Knowledge diffusion	Framework conditions for high-tech starters	Human mobility	Improving exploitation of public knowledge	Total per delivery mechanism
Finland									
Tax facilities									0%
Subsidy schemes		46%						<1%	47%
Credits and loans	47%		<1%			4%			51%
Brokerage and bridging institutions	1%							<1%	2%
Integrated packages				<1%		<1%			0%
Total per policy objective	48%	46%	<1%	<1%	0%	5%	0%	1%	100%
France									
Tax facilities	29%								29%
Subsidy schemes	<1%	8%		8%		1%	8%		25%
Credits and loans	16%		14%			2%			32%
Brokerage and bridging institutions									0%
Integrated packages				12%		2%			14%
Total per policy objective	46%	8%	14%	20%	0%	5%	8%	0%	100%
Netherlands									
Tax facilities	54%								54%
Subsidy schemes		18%			1%			2%	22%
Credits and loans			10%						10%
Brokerage and bridging institutions		5%		5%	1%				11%
Integrated packages						3%			3%
Total per policy objective	54%	23%	10%	5%	2%	3%	0%	2%	100%
UK									
Tax facilities	28%							7%	35%
Subsidy schemes	<1%	3%		5%	<1%			21%	29%
Credits and loans			2%						2%
Brokerage and bridging institutions				1%	2%			<1%	4%
Integrated packages			15%	15%		<1%			30%
Total per policy objective	28%	3%	17%	21%	3%	0%	0%	28%	100%
Australia									
Tax facilities	30%								30%
Subsidy schemes	18%	4%	3%	1%		4%			31%
Credits and loans									0%
Brokerage and bridging institutions				<1%	<1%				1%
Integrated packages	24%	3%		3%	3%	2%		3%	38%
Total per policy objective	72%	7%	3%	5%	4%	6%	0%	3%	100%
New Zealand									
Tax facilities	87%					1%	5%		94%
Subsidy schemes									0%
Credits and loans									0%
Brokerage and bridging institutions									0%
Integrated packages	6%								6%
Total per policy objective	94%	0%	0%	0%	0%	1%	5%	0%	100%
USA									
Tax facilities	25%								24%
Subsidy schemes	25%	2%		2%	1%	10%	1%	2%	42%
Credits and loans			<1%			<1%			<1%
Brokerage and bridging institutions	1%	2%		2%	2%		1%	1%	9%
Integrated packages	7%	4%		4%	4%		2%	4%	25%
Total per policy objective	57%	8%	<1%	8%	7%	10%	4%	7%	100%

Notes: All figures are estimates for the following years: Netherlands (2000); Australia (2000-01); Finland (1999); France (1997-99); New Zealand (2000-01); UK (2000-01); USA (2000)

Source: Adapted from Boekholt, P. et al *(2001), 'An international review of methods to measure the relative effectiveness of technology policy instruments', Technopolis B.V., Amsterdam*

Direct subsidies to single firms are still commonplace in the USA and Australia, but their significance has waned in the other countries. In France and Finland, for example, much more emphasis is placed on the use of credits and loans, though subsidies are still used, particularly in Finland and the Netherlands, to support collaborative R&D. For the EU countries too, it should be noted that collaborative R&D subsidies are also available via Framework Programme funding.

The remaining budgets in all the countries are spread quite thinly over a broad range of measures and policy objectives, with the spread most noticeable in the USA (53% of the budget is spread over objectives other than support for R&D projects in single firms) and least so in New Zealand (only 6% on the corresponding set of objectives). There are few commonalities in the pattern of expenditure across the countries and few highlights other than the 14% spent by France and 10% by the Netherlands on credit and loan schemes designed to counter the high risks associated with high technology start-ups; the 21% spent by the UK on schemes designed to enhance the exploitation and commercialisation of public sector R&D; and the 10% spent in the USA on initiatives designed to improve the framework conditions for high technology starters.

Another point worthy of attention is the growing focus on integrated packages, i.e. programmes which contain a variety of delivery mechanisms targeted at specific groups, sectors, regions or problems. These take up 38% of the budget in Australia, 30% in the UK and 25% in the USA. In the UK, integrated packages aimed at increasing the absorptive capacity of industry (i.e. the ability of companies to adopt and utilise innovations effectively) account for 15% of the budget, with France spending 12% on similar initiatives. A further 15% of the UK budget is spent on integrated packages designed to support high tech start-ups.

Although the patterns of expenditure differ across countries, valuable lessons concerning the issue of appropriateness can be drawn from an examination of the rationales determining the policy mix in individual countries. The relative absence of credit and loan schemes or measures addressing mismatches in risk capital markets in the USA, for example, has much to do with the lack of market failures in these areas and the relative ease with which firms can gain access to capital in the absence of public measures. This contrasts markedly with the corresponding situations in Finland and France, where the public sector's use of credit and loan schemes compensates for the conservatism and risk avoidance of private sector financial institutions. In the UK, measures to stimulate risk capital markets play a similar role.

Similarly, the distinctive pattern of expenditure in Finland, with 98% of the budget going almost equally to support for R&D projects in single firms and to collaborative projects, is a consequence of weaknesses in its industrial structure (very few large research-intensive MNCs, a modest number of medium sized forms and many SMEs with limited R&D capabilities) and the result of a determined effort to increase the technological capability of industry in key areas over and above all other policy objectives. For example, many of the programmes launched by TEKES, the Finnish National Technology Agency, thus contain collaborative projects that are deliberately meant to encourage collaboration between pivotal firms such as Nokia, members (actual and potential) of its supply chain and key centres of academic and public sector research excellence. In parallel, other schemes ensure that credits and loans are available to support work at the commercialisation end of the spectrum.

In distinct contrast, countries such as the UK and the USA employ a much broader spectrum of instruments precisely because relative weaknesses in their innovation systems are less focused and more diffuse and varied. The requirement, here, therefore, is for multiple instruments to tackle multiple problems, fighting fires as and when they arise. This also highlights the temporal aspect of policy mixes, for appropriateness obviously varies over time as some fires are extinguished and others ignite. During the 1970s, the UK made extensive use of single firm R&D support schemes but shifted the policy focus to collaborative R&D schemes in strategic areas during the 1980s and 1990s in an attempt to grow competence in specific technologies via strategies based on knowledge sharing. Latterly, however, national support for collaborative R&D has waned (compensated for in part by the strong involvement of UK firms and institutions in EU-wide schemes) and been replaced by policies designed to raise overall R&D levels via non-sector specific tax incentives.

5.2 Policy Mixes for Stimulating R&D Investment

Although hints and tips concerning the appropriateness of particular types of instrument can be picked up from a careful analysis of the drivers governing the formulation of particular national policy mixes, the main lesson is that the most appropriate policies are always based on a sound analysis of the problems pertinent to any one context.

In this spirit, Exhibit 5.2 is based on the analysis in Section 2 of the EU R&D investment dilemma and the reviews of policy instruments and related issues conducted in Sections 3 and 4. In short, it maps policies onto problems, indicating via a simple colour scheme the suitability or relative importance of particular policy instruments to the solution of some of the problems which currently underpin the relatively low R&D intensity of the EU compared to the USA and Japan, and which have to be resolved if the EU is to close the gap over the coming years. **It is based on an EU-wide perspective and should not be misinterpreted as a prescription for individual national or regional policy mixes. It simply depicts the aggregate picture to which the sum of EU policies should aspire if the EU is to rise to the 3% challenge**.

The problems to be resolved are those first outlined in Section 2, namely:

- Making the EU an attractive location for highly R&D-intensive MNCs to consolidate or relocate R&D capacity;
- Increasing R&D investment amongst the existing population of moderately R&D-intensive indigenous firms;
- Creating a favourable environment for new and existing R&D-intensive SMEs;
- Initiating R&D activities in traditionally low R&D intensive firms and sectors.

In turn, the policies represented in the Exhibit are the most important of those discussed in Section 3, i.e. those relating to Framework Conditions, and Section 4, i.e. financial and fiscal instruments.

It is obvious from even cursory scrutiny of the Exhibit that no one instrument is highly relevant to the solution of policy dilemmas in all four problem areas. Some policies are considered important to problem resolution in all areas, but none are considered highly relevant in all four areas. Similarly, each problem area is likely to require a very different combination of policy instruments in its resolution. Consider each problem area in turn:

Exhibit 5.2 Matching Policies to Problems

	Attracting MNC R&D Capacity	Increasing Existing R&D Investment	Creating R&D Intensive SMEs	Initiating R&D in Low-tech Sectors
R&D and Innovation Policy Types				
Direct Financial Measures				
Grants for Industrial R&D	Important	Important	Less Important	Less Important
Collaborative R&D	Important	Very Important	Less Important	Less Important
Public Procurement	Very Important	Very Important	Important	Less Important
Indirect Fiscal Measures				
Volume Measures	Important	Very Important	Less Important	Important
Incremental Measures	Less Important	Less Important	Less Important	Less Important
Catalytic Financial Measures				
Risk Capital Measures	Less Important	Important	Very Important	Very Important
Loan Guarantees	Less Important	Important	Important	Very Important
Equity Guarantees	Less Important	Important	Very Important	Important
Other Direct Measures				
Information and Brokerage	Less Important	Less Important	Very Important	Very Important
Awareness Schemes	Less Important	Important	Important	Very Important
Networking Measures	Important	Important	Very Important	Important
Co-location Measures	Important	Important	Very Important	Important
Framework Conditions and Policies				
Public Research				
University Research Funding	Important	Important	Important	Less Important
Infrastructure Support	Important	Important	Important	Less Important
Centres of Excellence	Very Important	Important	Important	Less Important
Human Resources				
Increasing Numbers	Important	Important	Important	Important
Increasing Quality	Very Important	Important	Important	Important
Increasing Mobility	Important	Important	Less Important	Less Important
Entrepreneurship				
Broad-based Promotion	Less Important	Less Important	Important	Important
Targeted Promotion	Less Important	Less Important	Very Important	Important
Intellectual Property Rights				
Community Patent	Important	Important	Less Important	Less Important
IPR regimes for PROs	Less Important	Less Important	Very Important	Less Important
GMO and Software Patents	Important	Important	Less Important	Less Important
Standards and Regulations				
Reduction of Regulatory Burden	Very Important	Important	Less Important	Less Important
Creation of Lead Markets	Very Important	Important	Less Important	Less Important
Competition Policy				
Favourable State Aid Rules	Important	Very Important	Less Important	Less Important
'Innovation-friendly' Decisions	Important	Less Important	Less Important	Less Important
Macroeconomic Conditions				
Stable Growth	Important	Important	Less Important	Less Important
Availability of Capital	Less Important	Important	Very Important	Very Important
Flexible Labour Markets	Important	Less Important	Less Important	Less Important
Systemic Solutions				
Technology Platforms	Important	Important	Important	Important
Cluster Policies	Important	Important	Important	Important

Key: Importance of Policy Instrument

(black)	Very Important
(dark grey)	Important
(light grey)	Less Important

5.2.1 Attracting MNC R&D Capacity

The most important and relevant policy instruments here are probably those designed to boost capabilities in public sector research and educational establishments and increase the potential for their interaction with industry. Industry is attracted by critical masses of brainpower that it can either collaborate with or recruit. Human resource policies to improve the quality of R&D personnel and policies designed specifically to concentrate these human resources in a few centres of excellence of world renown are both very important ingredients. The existence of collaborative R&D initiatives is not in itself a powerful enough incentive for MNCs to relocate, but they are still important channels allowing access to the science base once industrial research units have been established. State Aid rules that treat industry-oriented R&D in such programmes more generously would also be looked upon favourably by large MNCs. Public procurement policies that emphasise innovation and demand R&D inputs are also potent instruments, for these can act as strong incentives for MNCs to locate R&D capacity near to the source of lucrative markets. The lead markets that procurement policies can create are also powerful magnets for MNCs wishing to learn from foreign lead customers. Favourable regulatory environments that both reduce the regulatory burden on firms and encourage the growth of new lead markets are also an attractive proposition. Finally, in addition to all these very important measures, numerous other support mechanisms and changes to framework conditions would also contribute greatly to the overall goal of making the EU a more attractive place in which to conduct R&D.

5.2.2 Increasing Existing R&D Investment

Some of the most critical instruments used to attract MNCs to expand R&D capacity in Europe are also eminently capable of raising R&D investment levels in other types of indigenous R&D performer. Favourable State Aid regimes, innovative public procurement policies and collaborative R&D programmes all have a very important part to play. Tax incentive schemes can make a critical contribution too, especially volume-based measures applicable across the board to all R&D performers. Many policies affecting framework conditions can also be of great consequence, especially those affecting the macroeconomic and financial climate and access to investment capital. Risk capital and guarantee measures addressing problems related to lack of capital for R&D are relevant even for some of the larger and more well established R&D performers. Another critical factor affecting R&D investment levels is the low perceived importance of R&D and innovation within senior management circles. In some EU countries, the potential role of R&D and innovation in the overall long-term performance of firms is both underappreciated at this level and dwarfed by concerns about short-term rewards. Targeted efforts to raise awareness may be needed to foster the required cultural shift, though there may also be scope for changes in company law and accounting practices that encourage companies to treat R&D as an investment rather than as a cost.

5.2.3 Creating R&D Intensive SMEs

The spectrum of policies suited to the creation and nurturing of R&D intensive SMEs, NTBFs and start-ups is still very broad, but the focus is very different. Catalytic financial measures play a critical role in facilitating access to capital, some of which can be used for R&D projects. Other important instruments, however, include a range of direct measures designed not only to provide finance for R&D, but also to support a broad range of innovation and business activities. These include information and brokerage schemes to help overcome information deficiencies and broaden the opportunity base for firms, and networking and co-location measures to encourage interaction with external sources of complementary expertise. Measures to improve the public research base, commercialise public sector R&D outputs and stimulate spin-off activity from universities and other Public Research Organisations are obviously important too, as are IPR regimes that motivate such behaviour.

5.2.4 Initiating R&D in Low-tech Sectors

Many firms in traditionally low-tech sectors neither need to perform nor to have access to R&D. In some sectors, however, there is little doubt that higher levels of innovation and an enhanced R&D capability would strengthen overall performance, though the barriers are plentiful and steep. Not all firms perceive the need for R&D, or the benefits likely to accrue from it, and even when they do they are greatly constrained by lack of experience, lack of personnel, lack of suitable contacts, lack of information and lack of money. Appropriate policies, therefore, all stem from attempts to rectify these deficiencies. Schemes to raise awareness of the relevance and potential benefits of innovation and R&D are crucial. So too are information and brokerage schemes and catalytic financial instruments which improve access to capital. Also important are secondment and bootstrapping schemes that 'seed' technological innovation and R&D by parachuting qualified scientists, technologists and researchers into firms with little track record in these spheres.

Changes in the definition of R&D could also stimulate not only R&D activities in these sectors, but also improvements in innovative and economic performance. In both manufacturing and service sectors, but in the latter in particular, innovation in the sense of work organisation changes, new modes of management – including knowledge management – and the introduction of new business models is having an increasingly positive effect on overall performance. Much of the 'social science' research that should ideally underpin many of these changes, however, is neither carried out by firms nor accessed by them, and even if it were it would not qualify for support from many of the R&D support schemes currently in existence. Making such research eligible for support might allow more firms to benefit from resultant improvements in their innovative and economic performance.

5.3 Focused Policy Combinations

Once the most essential ingredients of a broad policy mix capable of tackling a specific problem – the creation of a dynamic, R&D intensive, high tech SME sector – have been identified, the next steps in the construction of Focused Policy combinations involve examining the suitability of individual policy mechanisms in different contexts and consideration of the ways in which these instruments might interact.

Exhibit 5.3 summarises some of the characteristics of the financial and fiscal instruments reviewed in Sections 4.1 – 4.4. It can be used to identify potential policy solutions once specific weak points in regional, national or international innovation systems have been identified. If, for example, there are relatively weak risk capital markets in a given context – which is still very much the case in many EU and accession countries – then there is a role for Equity Guarantee Mechanisms in particular to stimulate the development of these markets. Likewise, countries with low R&D levels and high corporate taxation might

Exhibit 5.3 Financial and Fiscal Measures: A Summary

	Direct Measures	Indirect Fiscal Measures	Risk Capital Measures	Loan and Equity Guarantee Measures
Financial Flows	• Finance direct to firms and/or to partners and intermediaries	• Income forsaken by public sector	• Finance to intermediaries	• Finance to intermediaries
Specificity	• Targeted at all types of firm, with increasing emphasis on SMEs • Applicable at many point in the innovation chain • Applicable in many geographical settings • Some instruments support R&D projects directly, others more indirectly	• Generic instrument capable of affecting all R&D performing firms, though often customised differently for large and small firms • Not always appropriate for early-stage firms Can be used for innovation but primarily used to influence R&D activity directly	• Ultimate beneficiaries are innovation-oriented SMEs, NTBFs, Start-ups, Spin-offs • Many measures targeted at different deficiencies • Finance accessed can be used to fund R&D • Influences R&D activity by enhancing the prospects for commercialisation, thus stimulating future R&D activities in the target audience and other firms and sectors	• Targeted at innovation-oriented SMEs (loan guarantees) and NTBFs, Start-ups, Spin-offs (equity guarantees) • Equity guarantees useful in regions with low levels of VC activity • Loan guarantees useful in risk averse environments • Finance accessed can be used to fund R&D • Influences R&D activity by enhancing the prospects for commercialisation, thus stimulating future R&D activities in the target audience and other firms and sectors
Deficiencies Tackled	• Scare Resources • Insufficient Incentives • Missing Capabilities • Lack of Opportunities	• Scarce Resources	• Scarce Resources • Insufficient Incentives • Missing Capabilities	• Scarce Resources • Insufficient Incentives
Potential Impact	• Modest direct leverage • Respectable additionality • Long-term strengthening of many innovation system components due to rectification of multiple deficiencies	• Modest direct leverage • Modest additionality likely • Impact and effectiveness difficult to determine • Impact greatest when benefits accrue directly to R&D departments	• High potential leverage since measures stimulate other financial sources to support R&D • Low impact in the short term since R&D spend in target audience is low • High impact in long term if greater incentives to innovate lead to higher R&D intensity	• High potential leverage since measures stimulate other financial sources to support R&D • Low impact in short term since R&D spend in target audience is low • High impact in long term if successful in establishing new VC markets
Pros	• Can be targeted to rectify many specific weaknesses • Relatively simple to design effective mechanisms • Limited time horizon an advantage to public authorities	• Generic tool to increase R&D volume • Accessible to a broad audience • Choice of R&D in hands of the firm • Low administration costs • Can offer a stable incentive over long periods of time, which helps firms plan R&D activities	• Can enable new entrants in particular to access risk capital • Help bridge gap between R&D and commercialisation • Can improve interaction between the business and technology worlds	• Equity guarantees help stimulate creation of VC markets • Reduce barriers to investment in venture capital funds
Cons	• High administration costs • Limited to a narrow audience • Limited time horizon a disadvantage to industry • Selection sometimes problematic • Limited by public spending constraints	• Difficult to ensure additionality • Possibility of windfalls • Can target SMEs, large firms, firms outsourcing R&D to universities etc., but can complicate overall tax regimes • Need to design in credit mechanisms when profits low or negative • Can be difficult to design	• Many different types and combinations of instruments needed to tackle different types of gap • Need to customise instruments for different settings • Potential distortion and displacement effects on private market	• Equity guarantees less effective when VC markets well established • Fairly complex to design • Can be costly to administer • Could distort private market
Importance	• Indispensable suite of policy tools	• Complementary rather than essential policy tool	• Growing need for bridging instruments of this type	• Equity guarantees specially needed to establish new VC markets
Focused Policy Issues	• Can be complemented by generic measures if levels are adjusted	• Can complement targeted measures (though can also negate if too high)	• Link with Direct Measures important if deal flow for seed investors is to be increased and capability and information deficiencies rectified • Can complement/ substitute for Guarantees once VC markets mature	• Need to be replaced by other risk sharing mechanisms when VC markets mature • Can be used as a substitute for tax credits • Can be used with other Risk capital measures to improve the environment for early stage capital
Holistic Policy Issues	• Highly dependent on the existence of a strong science base, adequate stocks and flows of R&D staff, IPR regimes which encourage exploitation, competition regulations and State Aids regulations	• Has to match highly diverse national tax regimes	• Greatly affected by framework conditions/mechanisms such as IPR, employment conditions for entrepreneurial academics, company tax regimes	• Greatly affected by macroeconomic policy, financial system regulations, State Aid regulations and the climate for entrepreneurship and innovation

consider fiscal R&D schemes based on corporate tax reductions, whereas countries with high labour and social costs should consider basing R&D tax incentives on these instead. Countries with highly complex tax systems, on the other hand, should weigh the potential benefits of introducing R&D tax incentives against the disadvantages accruing from even more complicated systems. Concerning direct measures, their variety and potential to target multiple weak spots make them the indispensable core of any policy portfolio. Cumulatively, however, they are relatively expensive to fund and administer and require considerable efforts in terms of intelligence gathering and selection procedures if they are to be targeted correctly.

The construction of a Focused Policy package should consider not only the appropriateness of specific ingredients, but also their interaction with each other. Three interactions in particular need to be highlighted.

5.3.1 Direct and Indirect Fiscal Measures

The use of Direct Measures that attempt to rectify financial resource deficiencies via the use of grants for R&D projects can interact both positively and negatively with Indirect Fiscal Measures such as R&D tax incentives. From the point of view of the public sector, their combined use has many potential advantages. Tax incentives offer the promise of raising R&D investment volumes along a broad front, whereas grant schemes can be designed to tackle very specific problems in areas of strategic importance. These are important considerations in the design of policy portfolios. From the point of industry, the autonomy of choice offered by generic tax incentive schemes is often complemented by the availability of additional cash via Direct Measures to initiate work in areas it considers to be important too.

There are limits, however. If tax incentives are too high, the attraction of grants diminishes unless these are very high too, but then the combined drain on public resources is often unacceptable. Conversely, when grant levels and tax incentives are both too low, neither is sufficiently attractive to motivate industry to invest in more R&D. If there is a perceived need for both types of instrument within a particular innovation system context, these considerations of balance have to be borne in mind.

5.3.2 Risk Capital and Loan and Equity Guarantee Measures

Both of these sets of measures have an important and complementary part to play in the process of encouraging investment in the commercialisation of R&D, the success of which increases the incentive to undertake research activities and eventually impacts on aggregate R&D investment levels. Both measures also have more immediate impacts on R&D levels, since many R&D intensive recipients of risk capital and the beneficiaries of guarantee schemes use the capital accessed to finance R&D activities. Guarantee mechanisms offer to share losses, thus reducing exposure to the risks involved in early stage investment. Loan guarantees are well suited to the support of established SMEs in risk averse contexts, whereas equity guarantees are well suited to environments where risk capital markets are poorly established. Once these become more established, however, loss-sharing schemes have a tendency to distort markets. In such situations, other risk sharing mechanisms are preferable. From a portfolio perspective, it therefore makes sense to consider the phased application of first equity guarantee and then other risk capital measures in the transition from immature to mature risk and venture capital markets, and to exploit loan guarantee instruments in highly risk averse environments.

5.3.3 Direct Measures and Risk Capital Measures

There is a well-recognised gap in support coverage between the R&D stage of the innovation chain and successful exploitation. Although finance via Direct Measures is often available for R&D with commercial potential, it is rarely available directly from public sources for the initial exploitation stages when commercial feasibility has been demonstrated but risk levels are still very high. Unfortunately, much risk capital from private sector sources is only usually available when risk levels are appreciably lower, i.e. when exploitation is considered probable rather than simply possible.

Many of the risk capital measures that tackle the pre-seed gap attempt not only to provide finance, but also to provide advice, mentoring and many other support services. These lie at the interface with many instruments falling under the heading of Direct Measures and deserve to be considered as a continuous part of the support spectrum. Often it is not enough, however, to offer a range of independent, autonomous support services covering the R&D and commercialisation gap. From the perspective of a firm, the offer of different support services has to be as seamless as possible if discontinuities are not to be introduced into the innovation process. This calls for more effort on the part of support agencies to ensure that their offers are as integrated as possible from the perspective of the beneficiary.

5.4 Holistic Policy Combinations

While Focused Policy solutions involve the careful selection of individual policy instruments and their use in combination with complementary 'near neighbours' in the broad policy spectrum, Holistic Policy solutions involve more complex policy portfolios tackling a much broader range of problems in different innovation system domains. These are correspondingly more difficult to construct, though there have been a number of attempts in recent years to evolve portfolios of this nature. Most noteworthy are the systemic policies labelled 'cluster' policies and those embracing the concept of 'technology platforms'.

Although cluster policies and policies to support the development and roll out of technology platforms have not so far been specifically aimed at raising private sector R&D investment, they are nevertheless important in terms of the development of Holistic Policy combinations for two main reasons. In the first instance, both are examples of the kind of thinking and general systems approach that underpins the conceptualisation and formulation of Holistic Policy packages. Secondly, many of the instruments currently used in the implementation of cluster policies around the world are similar in nature to those likely to be included in packages designed to raise private sector R&D levels. Many lessons about the efficacy of different combinations of instruments could therefore be learnt from experiences to date with existing cluster policies. Fine-tuning rather than the introduction of radically new policy packages might also be possible. The one proviso is that few detailed evaluations of the efficiency, effectiveness and impact of cluster and technology platform policies currently exist. This is the main reason these systemic policies are classified as important rather than very important in Exhibit 5.2. The suspicion, however, is that they could be very important indeed.

5.4.1 Technology Platforms

Firms operating in areas that involve complex system technologies (e.g. computing and telecoms companies) have long recognised the need for 'technology platforms'. At any one time these define the parameters and technical standards of a given technological system and allow the development of system components and sub-systems to take place within its boundaries. R&D is then devoted both to the short-term development of new products and processes within these boundaries, and to the definition and evolution of next generation technology platforms, sub-systems and components.

In terms of the evolution of technology platforms within such complex system technology areas, *de facto* standards for technology platforms have often emerged as the natural result of competition in the private sector, either between individual firms or, increasingly, between rival global consortia in the most complex system areas. The public sector has also had a part to play, however, in the evolution, acceptance and roll out of particular technology platforms, notably via its role as a sponsor of R&D; via its role as customer and lead market for new technologies; and via its role in the definition of new standards and regulations in fields such as telecommunications. Increasingly, therefore, there has been greater call for public-private partnerships to ensure the smooth adoption and roll out of new technology platforms. In turn, this has involved the constitution of policy portfolios that involve support for R&D projects; networking initiatives that facilitate the sharing of knowledge about potential new platforms between the actors involved in their development and subsequent use; the establishment of fora to discuss and negotiate new standards and regulations; and public procurement initiatives to establish lead markets.

Over time, the importance of the networking, information sharing and consultation processes associated with the development of these platforms has led to their gradual incorporation into current definitions of the concept itself, with a corresponding extension of its applicability. Whereas the term 'technology platform' was initially associated with notions such as technical compatibility in complex system technologies, the concept is now used not only to describe the set of normative 'rules' which define the relationships between various elements in a technical 'system', but also to describe the social processes involved in determining the future direction of developments in a scientific and technological area – and not just in areas associated with large complex system technologies. In particular, the term technology platform is now often used to describe the various processes involved in discussing and deciding policy priorities and action plans in areas as diverse as GMOs, cloning and energy systems.

The importance of this broader notion of a technology platform has been recognised by the EU, which is considering setting up technology platforms to work out long-term strategies for R&D in specific technological areas involving major economic and societal challenges. The aim is to ensure synergy amongst stakeholders such as public authorities, users, regulators, industry, scientists and consumers. Initiatives would review problems and opportunities, establish EU level visions and propose action plans for both the public and private sector.

Technology platforms are particularly relevant to the task of raising R&D investment levels because of their critical contribution to the development of new lead markets in areas such as biotechnology, nanotechnology and the hydrogen economy. All require the development of appropriate standards and regulatory frameworks capable of encouraging rather than discouraging R&D and innovation, which in turn requires intensive interaction between all relevant stakeholders if lead markets are to develop.

5.4.2 Cluster Policies

'Cluster' policies are essentially a child of the 1990s. They involve portfolios of policies designed to improve overall system performance. The systems in question can range from national economic and innovation systems to regional systems and even to systems that cross or transcend geographical boundaries. A distinction can also be made in terms of the analytical focus used to define appropriate policies for these systems. According to Boekholt and Thuriaux (1999), policies – and the analyses upon which they are based – can focus on:

- The industrial sectors in a national economy that contribute to national competitiveness (Mega Focus);
- The set of industrial sectors in any one setting that are linked together in value chains (Meso Focus);
- The set of firms and other actors that are linked together in any one particular value chain (Micro Focus).

The improvements sought in different contexts also vary, with four typical aims being:

- The improvement of national competitiveness and comparative advantage;
- Regional development;
- The strengthening of R&D and innovation linkages between industry and public research organisations (PROs, universities and government labs);
- Improvements in inter-firm networking.

Countries that have developed cluster policies with these aims are depicted in Exhibit 5.4. Countries such as Denmark and Finland have attempted to base national policies on comprehensive appraisals of the contribution of all sectors to national competitiveness, whereas in the Netherlands, for example, cluster approaches have been used to structure regional development policies and to strengthen industry-PRO links. In other countries, e.g. Ireland, cluster approaches based on micro-level analyses of firms' value chains have been used in efforts to increase inter-firm networking

Exhibit 5.4 Cluster Policies in Different Countries

Policy Aim	**Focus of Policy Analysis**		
	Mega Focus (All sectors in a system)	Meso Focus (Connected sectors in a system)	Micro Focus (Connected actors in a system)
National Advantage	Denmark Finland		
Regional Development		Canadian Provinces UK Regions US States	Netherlands Regions
Industry-PRO Links		Germany Netherlands	Austria Sweden
Inter-firm Networking			Austria Ireland New Zealand Norway

Source: Based on Boekholt, P. and Thuriaux, B. (1999), 'Public Policies to Facilitate Clusters: Background, Rationale and Policy Practices in International Perspective', in OECD (1999), Boosting Innovation: The Cluster Approach, Paris: OECD

Not surprisingly, the policy instruments incorporated into particular cluster policy packages vary not only from one context to another, but also with the policy aim and the analytical focus used to structure the approach. Cluster policies at a national level concerned with the contribution of all sectors to national competitiveness thus tend to have a greater emphasis on policies which affect overall framework conditions than policies aimed, for example, at improving inter-firm networking between a specific set of actors, which can and often do involve a much greater emphasis on the use of more direct, hands-on measures.

In terms of stimulating private sector R&D levels, the exact constitution of the required systemic policies or Holistic Policy packages will also depend on the levels at which they are applied. At an EU level, for example, policy packages that emphasise the importance of tackling framework conditions are vital, whereas analyses and policy prescriptions at national and regional levels should place greater emphasis on more R&D specific instruments and combinations of instruments.

5.5 Delivery, Coordination and Governance Issues

The concept of Holistic Policy packages is important because it stresses the need for effective policy solutions to comprise a very broad mix of different policy instruments, some tackling the problem of raising R&D investment levels directly while others deal with framework conditions and attempt to influence the wholesale development of innovation systems. Identifying the most critical components of an appropriate mix and the ways they might be combined, along the lines indicated in Sections 5.2 – 5.4, are also important steps in the construction of an effective policy solution. It is equally, important, however, to consider the contexts in which these policy combinations ultimately have to be formulated and implemented. Given that many of the policy ingredients of an effective policy mix are the responsibilities of different public sector departments or ministries, often operating at different levels (regional, national and EU level) and aimed at different target audiences (MNCs, SMEs, financial institutions, intermediary organisations etc.), policy formulation and implementation are greatly affected by issues of delivery, coordination and governance. Some of the most important of these are touched upon below.

5.5.1 Streamlining

One of the latest trends in R&D and innovation policy circles is for governments to attempt to streamline the delivery of policies. There has been a tendency for the number of policy instruments in use to proliferate as greater understanding of the complexities of innovation systems has led to the incremental addition of policies rather than the replacement of existing policy sets with new ones. This process of accretion, however, has often led to duplication and, more worryingly, confused target audiences. While policy pluralism does provide potential beneficiaries with a great deal of choice in the selection of support measures appropriate to their needs, they can only exercise this choice if they are given sufficient information upon which to base their choice. Consequently, their ability to choose is constrained both when there is insufficient information and, on occasion, when there is information overload. Solutions to the problem which maintain a healthy variety of policy support mechanisms and deliver adequate levels of information about them to firms typically involve efforts to reorganise the delivery of instruments (fewer departments offering more coherent sets of support instruments) and better 'signposting' to ensure that these mechanisms are visible to potential beneficiaries. All developments such as these are likely to improve the delivery of the multiple policy instruments that comprise Holistic Policy packages aimed at raising private sector R&D levels.

5.5.2 Relevance to Industrial Needs

One common dilemma in policy circles is that programmes and policies that fulfil a distinct policy need are sometimes unattractive to potential target audiences because they do not identify with this need. Efforts to increase R&D levels could fall into this category and are likely to be unsuccessful if industry fails to identify with them. The prospects of this happening, however, are diminished within the context of Holistic Policy packages because these offer differentiated target audiences a range of potentially useful support measures – all of which make a partial contribution either directly or indirectly to the overall goal of raising R&D investment levels.

5.5.3 Exceeding State Aid Intensity

One of the potential problems associated with the offer of multiple policy support instruments to firms is that individual firms might take advantage of all of them and exceed State Aid intensity levels. A corollary is that the precautions and policing necessary to avoid this happening would be unduly expensive. In reality, however, these possibilities do not present a real worry. State Aid restrictions themselves only apply to specific sets of activities, and most of the policy instruments contained within Holistic Policy packages address different types of market or system failure and support different sets of activities. Very few instruments, for example, directly provide financial support for R&D projects, and even though there is the possibility that direct support for an individual project could in theory be complemented by a tax subsidy for the proportion spent by a firm on the project, and even by a small proportion of the risk capital made available to a firm as a result of public intervention, the overall consequences for the public budget are minimal and almost certainly outweighed by the leverage and additionality effects on overall levels of private sector R&D spend.

5.5.4 Horizontal Co-ordination between Departments/Ministries

Different ministries or equivalent public sector departments at national, regional and EU levels employ different policy instruments. Even within the domain of financial and fiscal instruments, some Direct Measures are often the responsibility of the ministries (or their equivalents) dealing with science and technology, while others fall under the umbrella of ministries of industry and innovation. In parallel, Indirect Fiscal Measures, i.e. tax instruments, are typically the responsibility of ministries of finance. With Holistic Policy measures, this situation is exacerbated even further via the involvement of ministries dealing with education, trade, competition, health, environment etc.

In some settings, the adoption of Holistic Policy measures could lead to a reallocation of responsibilities between public sector departments or even to their restructuring. Neither of these are prerequisites, however, and they may even be undesirable given the vast spread of policy domains involved. It will be important, however, to ensure that mechanisms are in place to provide adequate co-ordination during both the policy formulation and implementation phases. At a national level, inter-departmental committees are one obvious mechanism, especially if chaired by Heads of State – a situation justified by the fact that the target of raising EU R&D levels to 3% of GDP was set by the European Council. At the level of the European Commission, steps will also have to be taken to ensure that the different Directorates with an interest in the areas affected by Holistic Policy packages act in a coordinated and coherent fashion.

5.5.5 Policies at Regional, National and EU levels

Holistic Policy solutions designed to raise R&D investment levels can be formulated at a variety of levels. This in turn raises a number of issues concerning the balance of effort and responsibility between levels; the balance of effort and responsibility within levels; and co-ordination between levels. Some of the most important and relevant points which emerge from a consideration of the general literature on R&D and innovation policy developments are noted below:

- R&D and innovation policies have primarily been implemented at a national level across Europe, with one or two major exceptions. The importance of formulating and implementing R&D and innovation strategies at a regional level, however, is becoming increasingly recognised within the context of the development of knowledge-based societies;
- The amounts of public money available to support R&D and innovation related activities at a regional level (especially from the Structural Funds) are likely to grow as ever increasing numbers of regions see the necessity of developing knowledge-based orientations;
- As noted earlier, the complexion of Holistic Policy mixes is a function of the level at which they are formulated and implemented, with policy mixes at regional levels likely to place less emphasis on tackling framework conditions than policies framed at more aggregated levels;
- It follows that he EU level is probably the most appropriate level to tackle many of the problems associated with framework conditions;
- The complexion of Holistic Policy solutions should differ radically from one region (and nation) to another;
- There is a danger that many regions (and nations) will attempt to develop very similar R&D and innovation strategies irrespective of their starting points unless determined efforts are made to implement Holistic Policies based on a sound analysis of capabilities, needs and opportunities;
- The more limited numbers of stakeholders involved in regional systems make the task of formulating Holistic Policies in line with stakeholders' needs more manageable;
- Holistic Policies designed to raise R&D levels are likely to be most appropriate for, and successful in, those regions (and nations) where R&D intensity levels are already high;
- Policies with a much stronger focus on increasing absorptive capacity through education, skills development and competence building in areas where comparative advantages already exist (tourism and agriculture) are more important in areas where existing R&D intensity levels are low;
- The rise of the region as an important part of the policy delivery equation in Europe brings with it the threat of overlap and duplication of efforts pursued at national and EU levels. Within countries, national governments will need to strengthen co-ordination mechanisms between national and regional levels, while the European Commission could play an important part in facilitating the exchange of relevant experiences and policy lessons across both countries and regions.

5.5.6 Trade-offs between Policy Spheres

There are always trade-offs between policies in any one sphere and policies in another. More public expenditure on health and education, for example, can lead to less spend on defence. The European Council target of 3% for R&D as a percentage of GDP (with the public sector contributing a substantial proportion of this even if private sector expenditure increases) will thus have consequences for other policies if R&D expenditure rises in line with expectations, especially if countries keep to the overall public expenditure limits of 3% set by the Stability Pact. This in turn may lead to public pressure for a reversal of the stance of the European Council if expenditure is reduced in areas of greater perceived interest to the population at large. To counter this, public sector bodies should consider further actions to promote the public understanding of science and improved perceptions of the importance of science, technology and innovation in modern economies. Greater and more concerted efforts to raise private sector investment on R&D would also ease the pressure on public budgets in the long run.

A related trade-off stems from the tension that exists in the EU between the drive for greater competitiveness, higher levels of innovation and increased levels of R&D expenditure and policy goals such as the maintenance of European social welfare models and the development goal of cohesion. There is concern in some quarters that attempts to rival the US in terms of competitiveness and innovation performance can only be achieved via the adoption, for example, of much more flexible labour regulations and the erosion of the social welfare regimes which currently characterise much of Europe. Similarly, there are concerns that the greater concentration of R&D and innovation-related resources that may be necessary to raise R&D investment levels via the attraction of footloose R&D capacity will also lead to regional disparities. To some extent these are valid concerns, but neither the erosion of social welfare regimes nor gross regional disparities are inevitable consequences of attempts to raise R&D investment and improve innovative performance. Governments and the EU should nevertheless pay attention to these concerns in the design of Holistic Policies and carefully monitor developments during their implementation in order to inform future policy debates.

5.6 The Role of Strategic Intelligence

The task of formulating an appropriate policy mix to stimulate private sector investment in R&D requires intensive efforts to amass all the information necessary to make intelligent decisions. The analytical steps involved are quite straightforward. Data is needed in the first instance on the dimensions of the problem, e.g. comparative R&D intensity levels between different firm types, industrial sectors, regions and countries, and assessments are required of relative strengths, weaknesses, opportunities and threats. Potential routes to resolve the most pressing problems can then be identified and prioritised, e.g. a primary focus on efforts to attract MNCs to relocate R&D capacity and a secondary longer term focus on the creation of a dynamic high tech SME sector. The suitability of various policy instruments can then be compared, based on past assessments of relative efficiency, effectiveness and impact, and the most appropriate of these policy instruments mapped onto each of the priority problems. Consideration can then be given to the feasibility of combining the instruments into the Focused and Holistic Policy solutions needed to tackle all the identified problems.

In practice, however, the task is complicated by a number of data deficiencies: none of which are unexpected; all of which can be ameliorated. Some of the steps needed to improve the 'strategic intelligence' upon which sound policy formulation depends are discussed below.

5.6.1 Indicators

International organisations such as the OECD and the European Commission devote considerable efforts to the collection of time series data on R&D intensity levels in different countries. National organisations such as the National Science Foundation in the US also collect and publish such information. It is still difficult, however, to obtain adequate and commensurate time series data on R&D intensity levels across firm types and industrial sectors. This situation needs to be rectified if the accuracy of problem identification is to improve.

5.6.2 Evaluations

Many governments in the EU have established evaluation systems to review the appropriateness, efficiency, effectiveness and impact of different R&D and innovation policy instruments. These systems are probably most developed in the Scandinavian countries and the UK and least developed in some of the cohesion and accession countries. At other levels, the European Commission has made significant efforts to improve its evaluation system, while most regions have yet to initiate evaluation activities. Within all these systems, evaluation practices range from sophisticated efforts to learn from past experiences to mechanistic accountability exercises. Across the EU as a whole, however, despite pockets of excellence, there is still tremendous scope for improvement. In any one context it is still difficult to find evaluations of different policy instruments that allow comparisons of relative efficacy to be made, while comparisons of the use of similar instruments in different national and regional contexts are even harder to locate. There is little doubt that the process of policy formulation across the EU would benefit enormously from more concerted efforts to introduce comprehensive evaluation systems with a learning orientation.

Improvements in evaluation systems are also required to meet two new challenges. The first results from the increasing and recommended use of combinations of instruments to tackle both single and multiple problems within innovation systems. This will place new methodological demands on the evaluation community. The second challenge arises as a consequence of the drive to develop a European Research Area (ERA) and the adoption of the Sixth Framework Programme (FP6). To date, the Framework Programmes have primarily been a way of allocating funds to the research community across the EU, with programme aims couched in terms of scientific excellence and improved competitiveness. FP6, however, goes beyond this and constitutes an attempt to restructure and reorient scientific and technological activities much more broadly within the Member States. Efforts to evaluate the success of FP6, therefore, will have to go beyond conventional efforts to assess programme efficiency, effectiveness and impacts by aggregating the assessments of these entities at a project level. Instead, they will have to have an additional, primary focus on the changes in the structure, organisation, direction, level and quality of scientific and technological endeavours within Member States. This will invariably place demands not only on the Commission's evaluation system, but also on the evaluation systems of all Member States, since the only way assessments of this nature can be conducted is via coordinated, pooled efforts across the EU.

5.6.3 Benchmarking

The strategic intelligence needs of policymakers evolving appropriate policy mixes in different settings are tremendous. Data are required not only on policy performance and scientific, technological and innovation-related trends in any one setting, but also on similar trends and outcomes in other settings, preferably in a commensurate form that allows comparisons to be made and facilitates estimates of best practice. Just as assessments of the impact of FP6 on the fabric of European science and technology endeavours will require coordinated efforts across Member States, efforts to benchmark innovation system performance at regional, national and international levels will also necessitate a high degree of interaction and coordination between the relevant authorities if mutual learning is to occur.

If benchmarking demands coordination, it is also true to say that coordinated policymaking demands benchmarking. The Open Method of Coordination (OMC) has been proposed by the Lisbon European Council as a means of linking policymaking in the EU, and the application of this concept is currently being explored in the field of research and technology development. In essence this will involve the sharing of information about policy practices and intentions and the evolution of mutually supportive policies in the future. The link with, and need for, benchmarking is therefore palpable. If OMC is accepted in this field, coordinated approaches to policymaking are likely to benefit enormously from concerted benchmarking efforts across the EU. Conversely, efforts to benchmark innovation system performance will also be greatly enhanced and the utility of benchmarking exercises improved via the direct link with policymaking.

Care will have to be taken, however, to ensure that the results of benchmarking exercises are interpreted correctly and acted upon sensibly. A 'naïve benchmarking' approach, for example, would be to consider the current gap in R&D intensity between the US and the EU, set an aggregate target of 3% across the EU, and ask all Member States to pursue this target irrespective of other pressing problems within their own innovation systems. Alternatively, application of an 'intelligent benchmarking' approach would involve Member States considering how deficiencies in their own innovation systems (identified via the use of strategic intelligence tools such as evaluation and benchmarking) could be resolved via routes which would simultaneously raise R&D capacity. This may sound overtly optimistic, but is this really the case when we know, for example, that improvements in innovation performance and market success are major sources of R&D investment capital, and that dramatic improvements in the quantity and quality of researchers in a country can act as magnets for the footloose R&D capacity of MNCs?

To complete the cycle, policies adopted at a national (and regional) level would then be complemented by monitoring activities which would feed into collective benchmarking activities and complement strategic intelligence. In turn this would help improve regional and national policies and filter eventually into the negotiation of new and revised policy targets at a higher EU level. There is thus no necessity for 'naïve benchmarking' to lead to inappropriate policy solutions if 'intelligent benchmarking' approaches are used to set up a virtuous cycle of linked benchmarking and policymaking activities.

The adoption of an appropriate policy mix to reach the 3% target also has implications for benchmarking priorities in future. As noted throughout this report, much of the gap with the USA is caused by differences in industrial structure, with the US having a much higher proportion of large R&D intensive MNCs in high tech areas such as ICT and a greater proportion of high-tech firms generally than the EU. Any attempts to rectify these imbalances will therefore involve a range of policy measures, including attempts to attract MNCs to locate or relocate R&D capacity in the EU and efforts to stimulate the creation and growth of new, high-tech R&D intensive SMEs. In turn, these may involve attempts to improve the public research base via the creation of centres of excellence to rival Stanford, MIT, Harvard, etc. (all magnets for the co-location of industrial research labs); efforts to stimulate the dynamic clustering of MNCs, research labs and high-tech SMEs (which act as a breeding ground for start-ups and spin-offs); and efforts to improve the flow of graduates into research, since the 3% target is not likely to be reached if the quantity and quality of researchers in the EU do not increase dramatically. Suitable benchmarking topics and indicators for the 3% target thus include, amongst many other possibilities:

- Aggregate R&D intensity figures at EU, national and regional levels;
- R&D intensity data at industry sector level;
- R&D intensity data broken down by firm size and technological capability (high-tech, medium-tech, low-tech etc.);
- Comparative analyses of good practice in terms of policies to attract MNC research labs;
- Data on the changing distribution of centres of excellence across the EU
- Comparative analyses of good practice in terms of policies to stimulate new high-tech firm formation;
- Comparative analyses of good practice in terms of cluster development;
- Comparative analyses of measures designed to stimulate the flow of graduates into research;
- Data on the flow of graduates into research.

5.6.4 Future-oriented Activities

Whereas evaluation and benchmarking exercises have an eye on past performance and historical trends, assessing future opportunities and threats is also an important step in assessing the appropriateness of any policy mix. For the 3% drive in particular, foresight and similar exercises have a crucial role to play in matching prospective policies with current capabilities and future aspirations. Identifying technology 'hot spots' and estimating their potential for growth will be particularly important. In an EU context, it will also be necessary to explore the feasibility and desirability of different socio-economic scenarios for the future. The types of policy mix advocated in this report to raise EU R&D levels and intensity should lead to industrial restructuring and a reconfiguration of the science, technology and innovation landscape of the EU. The outcomes of these changes, however, are not predetermined in any way. They are socially determined. Efforts are needed, therefore, to sensitise the multiple stakeholders affected by these changes to the importance of contributing to the policy debate that will shape the resultant outcomes.

6.0 Conclusions and Recommendations

6.1 Rising to the Challenge

Radical improvements in the effectiveness of the mix of public support instruments for R&D are necessary if the EU is to reach the target figure for R&D intensity of 3% of GDP by 2010. 'Business as usual' is not an option. Even modest increases in the scale and adequacy of existing efforts to stimulate private sector investment in R&D – which is expected to account for two thirds of overall R&D expenditure by 2010 – will not be enough. The gap with the US in particular is widening, the incentives for industry to increase R&D investment in the EU are currently insufficient, and bottlenecks such as an inadequate supply of qualified researchers will continue to block progress towards the target unless drastic action is taken.

The European Council needs to be alerted as soon as possible to the fact that the private sector contribution to the 3% target set in Barcelona in March 2002 will not be realised without radical improvements in the existing mix of public support mechanisms for R&D.

Analysis of the causes of the gap and potential means of closing it indicate that much of it is due to industrial structure differences and deficiencies in the EU innovation system as a whole. In terms of the former, the US has larger proportions of high-tech companies and highly R&D-intensive MNCs in its industrial complexion and possesses the largest concentration of highly R&D-intensive ICT companies in the world. Prospects for the creation and growth of R&D intensive firms in biotechnology, nanotechnology and advanced new materials are also healthy. In comparison, the EU industrial structure has more low- to medium-tech companies and a larger share of R&D carried out by SMEs. To a large extent, closing the gap means rectifying these structural differences, which in turn calls for the implementation of a much broader suite of policies than those typically associated with support for R&D.

The nature of the gap calls for policies capable of instigating a wholesale shift from an EU industrial structure dominated by SMEs and low to medium-tech sectors to one with a larger proportion of high-tech sectors and R&D-intensive conglomerates working in conjunction with SMEs.

Although increasing the amount of R&D performed in the EU is a necessary condition for the EU to close the gap with the US and reach the Barcelona target, this will not be sufficient in itself for the EU to reach the Lisbon target of becoming the world's leading knowledge-based society. This will require many other initiatives aimed at rectifying deficiencies in the EU innovation system. These include efforts not only to strengthen the R&D base in the EU but also efforts aimed at improving the productivity of R&D, enhancing the ability of firms to exploit R&D activities, and promoting the widespread diffusion and absorption of innovations throughout the economy. The latter is a particular problem in the EU, but improvements in all these spheres are needed if the EU innovation system is to function efficiently and effectively – a necessary prerequisite for attaining the Lisbon target. Crucially, however, these changes are also needed if the Barcelona target of 3% is to be met. R&D investment levels are ultimately dependent on buoyant economies and realistic prospects of commercial success, which in turn require all parts of the EU innovation system to function harmoniously. Although setting a target for R&D intensity at Barcelona was a welcome step that has stimulated much constructive policy thinking, it now needs to be complemented by further efforts which focus on improvements elsewhere in the EU innovation system.

The European Council should be made aware that setting and attaining additional innovation system targets related to the supply of researchers, the exploitation of R&D and the diffusion of innovations are necessary next steps if both the Barcelona and Lisbon targets are to be reached.

The radical changes in EU industrial structure and the improvements in innovation system performance which are needed to attain the European Council's targets call for a much more integrated set of policies along a broader waterfront than has been the case hitherto. More than ever before, a holistic approach is needed in the construction of adequate policy portfolios. There is little doubt that traditional R&D support measures such as public sector subsidies for R&D projects or R&D-related tax incentives have a major part to play in stimulating private sector investment in R&D, but the deployment of these measures will be to little avail in the absence of parallel measures tackling external framework conditions. R&D investment behaviour is conditioned and modified in much the same way that general business behaviour is affected by general macroeconomic developments. Policy intervention in financial and labour markets can have critical impacts on the availability and flow of capital and labour. Competition policy can sometimes inhibit innovation and suppress R&D investment unless it is carefully framed and implemented. Standards and regulations and policies designed to protect intellectual property also require careful specification if they are to promote rather than inhibit R&D, and appropriate educational polices are vital not only to ensure sufficient supplies of scientists, engineers and researchers, but also to ensure that the general populace is sufficiently educated to appreciate and benefit from the fruits of science, technology, innovation and knowledge societies generally.

A holistic perspective is needed in the construction of policy portfolios if appropriate and effective solutions are to be found to the problem of low private sector investment in R&D.

A nested approach to the development and implementation of appropriate policy portfolios will also be needed. Whereas a holistic approach provides the 'helicopter' perspective needed to identify all the correct ingredients in a policy mix, these component policies will need to be implemented via more focused policy packages comprising one or more individual policy elements. In particular, many of these focused policy packages will need to link policy initiatives that tackle contiguous problems along innovation chains. Traditional R&D project support mechanisms for SMEs, for example, may need to be supplemented with complementary mechanisms that encourage growth and expansion at later stages in the innovation process, and policies designed to foster spin-offs, start-ups and NTBFs would undoubtedly benefit from complementary policies to encourage the development of clusters of high-tech SMEs, large firms and academic institutions.

Focused policy packages comprising sets of complementary policy instruments will be needed to ensure that actions designed to stimulate R&D activities are linked effectively to other innovation-related activities.

The adoption of holistic perspectives and the design of focused policy packages will invariably involve choices along many dimensions and decisions based on careful consideration of multiple options, competing needs and contextual idiosyncrasies. Some of these choices will involve finding an appropriate balance between the 'public sector good' and the 'private sector good'. R&D tax incentives, for example, benefit the private sector in the short-term and the public sector in the long-term if they do lead to increased R&D levels, but they only benefit the private sector if they fail to stimulate additional R&D and only subsidise existing activities. Checks are thus needed to ensure additionality, but these increase the administrative overheads for firms and act as a disincentive to participate. The trick, therefore, is to find an appropriate balance that enhances both public and private sector good. In other situations, the deciding factor in the choice of an appropriate policy instrument will depend on the social and institutional setting. Fiscal R&D incentives, for example, are less effective in countries with low corporate taxation levels, and tax incentives based on reduced income tax payments for individual researchers are well suited to environments attempting to attract researchers from other countries to relocate. The crucial point to appreciate in all of this is that there are no intrinsically 'correct' solutions or 'magic' policy prescriptions that are context independent. All depend critically on sets of constraints that are unique to particular locations and times, and choices that depend on satisfying and balancing the needs of multiple stakeholders.

There is no one prescription for a policy mix that can invariably improve the effectiveness of innovation systems and raise R&D investment levels. Choosing the correct prescriptions in different settings involves careful analysis of the nature of the problem in these contexts and an appraisal of the potential benefits of rival solutions. What works in one country might not work in another, and what works at the level of the EU should not be expected to work with the same efficacy in different Member States.

Although there is no one policy mix which will fit the bill in all Member States, it is possible to specify some of the problems which confront the EU as a whole and to suggest some potential solutions. Increasing R&D investment levels via a restructuring and reorientation of the EU industrial structure will at the very least involve attracting more MNCs to locate or relocate R&D capacity in the EU; the adoption of a strategic focus on particular high-tech technology sectors of current or potential importance; and concerted efforts to nurture a vibrant high-tech SME sector. Generating sufficient wealth to raise future R&D investment levels will also involve improving absorptive capacity via policies designed to stimulate the widespread diffusion of innovative products and processes throughout the EU economy. Tackling all these problems will require holistic approaches that involve policies operating on framework conditions and more conventional R&D stimulation instruments, often linked in nested or focused policy packages.

Even though appropriate policy mixes will vary from one Member State to another, there is ample scope for mutual learning in both the ways policy instruments can be selected and used and in the ways in which they can be combined.

6.2 Policies Affecting Framework Conditions

Resolving some of the problems currently besetting the EU will involve holistic approaches that incorporate policies tackling the following framework conditions:

- Macroeconomic Conditions;
- Competition Policy;
- Standards and Regulations;
- Entrepreneurship;
- Intellectual Property Rights;
- Human Resources;
- Public Research.

6.2.1 Macroeconomic Conditions

Low interest rates, stable growth rates and simple, transparent business tax regimes not only favour R&D investment by indigenous firms but also act as inducements for foreign-based firms to locate R&D activities in the EU.

Every effort should be made to maintain stable growth conditions and improve the transparency and commensurability of business tax regimes across the EU.

Access to capital needs to be improved in order to allow spin-offs, start-ups and NTBFs to flourish. It also needs to be available to other firms in times of economic downturn.

Public policies that help improve communication channels and flows between the financial sector and the R&D performing, innovative SME community are needed to improve understanding and facilitate better risk assessment.

Overall labour market flexibility affects technological progress and economic growth generally, with knock-on implications for business R&D levels.

Labour market practices and social security and pension systems need to be flexible enough to allow the transfer of people from low growth sectors to areas of high growth and productivity, given suitable retraining.

6.2.2 Competition Policy

R&D policy is meant to overcome market failure and EU State Aid rules for the support of R&D projects impose limits on the subsidies firms can receive in order to prevent market distortion. If these limits are drawn in the wrong place or phrased too harshly, the market failure can remain unresolved and competition policy can act as a brake on innovation and R&D investment. Given that there is a recognised political need to increase private sector investment in R&D, and in the absence of any credible objective tests to indicate whether or not a market failure has been resolved, there is a case for amending the current rules to increase the incentives for firms to participate in public sector sponsored R&D programmes.

EU State Aid rules for R&D should sanction a 50% business R&D aid intensity at a programme level and carefully evaluate any resulting rise in business R&D levels. Higher levels of 75% would be more

appropriate for programmes aimed at regional development and support for SMEs.

6.2.3 Standards and Regulations

Removal of regulatory barriers promotes competition in product markets, stimulates innovation and is likely to lead to increases in R&D intensity across the EU. Efforts are needed to remove such barriers, though not at the expense of other socio-economic goals such as environmental protection and sustainable development. If chosen correctly, however, even standards and regulations that safeguard and attain these goals can stimulate innovation and lead to increases in R&D activity.

The EU should attempt to remove the regulatory burden on firms by promoting, wherever possible, revised, less onerous European standards and regulations as global solutions, with harmonisation across the internal market a desired first step.

Regulations that seek to safeguard or attain socio-economic goals other than increased competitiveness should be chosen with their potential to enhance innovation and promote R&D activities in mind.

6.2.4 Entrepreneurship

A healthy and dynamic high-tech SME sector is more likely to flourish within a pervasive entrepreneurial culture. Compared to their US equivalents, however, EU financial institutions and entrepreneurs are more risk averse.

Broad-based efforts to promote an entrepreneurial culture exist in many countries but should be intensified significantly. These should include awareness raising initiatives, competitions and the inclusion of elements of entrepreneurship in school and university curricula.

6.2.5 Intellectual Property Rights

For Intellectual Property Rights to provide an adequate incentive to conduct R&D and innovate the administrative costs of acquiring and protecting them have to be low and the processes involved transparent and user-friendly. The absence of a Community Patent and slow progress towards harmonisation across the Member States have collectively acted to lower the incentive to invest in R&D in the EU.

The recent agreement on the introduction of a Community Patent is welcomed, but harmonisation of IPR regimes in Member States still needs to be accelerated.

Clarification of the ownership of IPR developed by academics when working in collaboration with industry in publicly funded programmes is a difficult issue to resolve, since there is a tension between the needs of existing industrial partners (who want to own the IPR) and those of academics eager to reap some reward for the exploitation of their intellectual capital.

One promising solution is for the Commission to develop a template for a default agreement that could be adopted within both national and EU

programmes, with all parties obliged to accept this agreement unless they can negotiate alternative agreements prior to the initiation of collaborative R&D activities.

Although Intellectual Property Rights constitute an incentive to conduct R&D and to innovate, they can also act as a restraint on the process of technology absorption across an economy. Given that rectifying deficiencies in absorptive capacity is a prerequisite for a healthy innovation system within the EU, it is vital that IPR regimes across the EU strike the right balance between the incentive to conduct R&D and the need to promote diffusion.

Further study is needed of the mix of policy instruments needed to ensure that IPR regimes both encourage R&D investment and promote diffusion. These might include: direct measures promoting the diffusion of protected research results; subsidising protection costs; subsidising litigation costs; brokerage and intermediation schemes; and support for licensing agreements.

6.2.6 Human Resources

Potential human resource shortages constitute a critical obstacle to the attainment of the Barcelona target. Not enough people are being attracted into either the study of science and technology or into associated careers, including research. There are also net flows of researchers from the EU to the US and inadequate flows from other parts of the world to the EU.

Urgent steps are needed to increase the attractiveness of science, technology and research as rewarding careers and to make the EU an attractive place to pursue them. This will involve action on the part of educational authorities and changes in fields as diverse as pension, immigration and mobility policy. Initiatives stimulating greater interaction between industry and the academic world will also be needed.

6.2.7 Public Research

A strong public research sector is vital for the existence of a vibrant business R&D community. It is a source of potential recruits and knowledge which can be developed by industry; it can act as a magnet for firms considering the EU as a location for R&D facilities; public research bodies are critical components of research intensive clusters and potential growth poles for the development of high-tech regions; and accessible sources of public research and knowledge can play a key part in the widespread diffusion of technology.

Efforts to reform public research systems in Member States will have to intensify. This will involve raising the status of researchers; improving incentive structures for public researchers to consider the innovation potential of their work and to collaborate with industry; and the removal of administrative and legal obstacles impeding the involvement of universities and researchers in the development of partnerships with industry.

Questions of balance and critical mass will have to be addressed at a European level if radical increases in R&D investment are to occur across the EU. This will call for the reformation of national R&D programmes to eliminate barriers to transnational collaboration between public R&D institutions in different countries, and to cross-border technology transfer between the public and private sectors. It will also call for new institutions and initiatives to strengthen the university sector across the EU, e.g. a European Research Council, transparent and comparable accounting systems and new Europe-wide competitions to promote research excellence.

A third of the R&D expenditure needed to meet the Barcelona target is expected to come from the public sector. This could leverage much of the additional investment needed from industry if it is allocated wisely. A significant proportion should be devoted to fundamental research, much of it concentrated into a select number of strategically important fields and centres or networks of excellence that would then be able to attract the best researchers in the world. Funding for joint academic-industry R&D programmes and networks in more applied areas should also be increased substantially, with improved incentives for academics to collaborate with industry, and a proportion should be reserved for maintaining and enhancing R&D capability within regional centres geared towards serving the R&D, innovation and technology absorption needs of local firms.

6.3 Financial and Fiscal Instruments

The main financial and fiscal instruments used either in isolation or in combination to stimulate business R&D investment are Direct Measures, typically involving the direct transfer of financial support from the public to the private sector, and Indirect Fiscal Measures, whereby the public sector forsakes tax income from the private sector in exchange for approved investment behaviour. In addition, Catalytic Measures such as Risk Capital Measures and Loan and Equity Guarantees can be used to improve access to external private sources of finance and stimulate the flow of investment funds both for innovation in general and for R&D.

6.3.1 Direct Measures

Direct Measures take many forms. They include grants and loans to firms to undertake R&D, often in collaboration with other research institutions; support for public research institutions to undertake R&D of relevance to industry; support for networking, co-location initiatives and information and brokerage schemes; support for R&D conducted as part of the procurement process; and systemic measures such as cluster policies which use a variety of instruments to encourage interaction and synergy between closely related actors in high-tech, R&D intensive sectors.

As the main instruments conventionally deployed to stimulate business R&D, they are of great potential importance in policy mixes designed to attain the Barcelona target and necessary complements, for example, to parallel measures to strengthen the public research base.

Key messages concerning the utilisation of Direct Measures are as follows:

R&D programmes which offer grants to firms are an indispensable part of the policy portfolios intended to strengthen R&D capability, leverage business expenditure on R&D, encourage networks and establish R&D intensive clusters. They are especially useful when they are highly visible, easily accessible to firms, and targeted at areas of contemporary industrial interest, and less so when the multiplication of such programmes causes confusion and targets are inflexible over time. **Good practice suggests small portfolios of flexible measures**.

The service sector dominates many modern economies and innovation in the provision of services is a key determinant of the health and growth of this sector. However, R&D related to service sector innovation rarely qualifies for support via the use of conventional Direct Measures, and investment in this area remains sub-optimal despite its growing importance. **Redefining the eligibility rules would stimulate R&D investment levels in this critical area**.

Policy instruments which attempt to link supply with demand have been relatively neglected in non-military arenas, despite the fact that public technology procurement entailing a measure of R&D is the largest potential source of the financial resources needed to meet the Barcelona target. **Public authorities should be encouraged to be less risk-averse and take steps to increase the amounts of R&D associated with procurement decisions**.

6.3.2 Indirect Fiscal Measures

Many countries use tax incentives as a means of stimulating R&D and schemes differ radically in different settings – often due to the need to make them compatible with the general fiscal environment in each location. They are well suited to raising R&D levels across the board and less well suited as a means of targeting specific sectors or technology areas. They are relatively economic to administer but run a greater risk than some other measures of subsidising work that would have been carried out in the absence of the incentive.

Key messages concerning the utilisation of Indirect Fiscal Measures are as follows:

Member States should amend current fiscal incentives for R&D or design new instruments in accord with current concepts of 'good practice', where design criteria emphasise simplicity, low administrative and compliance costs, reliability, and long term stability.

In keeping with these principles of good design, **tax incentive schemes should be volume-based (allowances based on the volume of R&D costs in a given period) rather than increment-based (allowances based on the increment in R&D costs from one period to another) if the main objective is to stimulate R&D investment substantially.**

Fluctuations in R&D investment as a consequence of fluctuations in overall business performance could be minimised via schemes which refund tax credits or tax allowances whenever companies make losses (and thus miss out on opportunities to benefit from a reduction of corporate income tax liabilities). For large firms, this could be dealt with via carry forward/carry backward mechanisms. For small firms, cash refunds are preferable since they have an immediate effect on cash flow.

There is a need for formal evaluations of the effectiveness of fiscal incentives and comparisons with the effectiveness of other types of policy instrument. These evaluations should be made publicly available for policy learning purposes. In order to perform effective evaluations, there is an urgent need for the compilation of databases containing information at the firm level.

6.3.3 Risk Capital Measures

Risk Capital Measures affect the flow and use of risk capital for innovation-related activities likely to increase R&D levels in the long-term, typically via routes which encourage investment in spin-offs, start-ups and NTBFs and the establishment of dynamic, high-tech, research-intensive SME sectors. As such they have a critical role to play in the necessary transformation of the EU industrial structure, though their efficacy is highly dependent on prevailing framework conditions such as the macroeconomic climate, the health of financial markets, tax regimes and IPR regulations.

Key messages concerning the utilisation of Risk Capital Measures are as follows:

Incubator/pre-seed activity in Europe is essential for risk capital deal flow and requires public support in order to be developed and sustained. The provision of support for technology-incubator/pre-seed activity converting more research projects to investment-ready business proposals needs to be enhanced across the EU. Such activity is not profit-generating and requires a sustained public contribution to its funding mix. **The Commission should call for and fund proposals for new, co-ordinated, trans-European incubator and pre-seed fund activities. Criteria for proposals should include a requirement for experienced, properly remunerated private management with an understanding of both technology transfer and investment processes. Proposals should be consistent with activity already existing at national and trans-national levels and should be of sufficient scale to ensure cost-effectiveness (e.g. regional level)**.

Europe has too few seed funds of an appropriate scale to operate effectively. In many Member States, seed funds for investing in R&D intensive start-ups are too small to be viable. By contrast, institutionally backed early-stage funds tend to be too large to be able to address this segment as part of their mainstream business. **Public resources should be made available to provide leverage to seed funds, on an experimental basis, at both national and trans-national levels. Variants of the US SBIC model could be adopted (as in Flanders), and other measures of subsidised or commercial leverage trialled (as in France). The Commission could become involved in evaluating and reporting on the effectiveness of various forms of leverage, possibly co-ordinating with the EVCA. In addition, the EIF should consider ways of increasing its impact on the provision of finance for seed funds across the EU that are consistent with its own financial mandate and its role as a managing agent for Commission resources. This could include relaxing the 50% limit on total public-sector participation in funds in markets where private co-finance for seed funds is particularly difficult to source**.

Institutional investors in Europe are unnecessarily cautious about early-stage funds as an asset category. Efforts are needed to overcome this reluctance to invest and to combat the information and perception gaps that underpin it. In particular, information on investment activity, manager track records and fund performance needs to be more detailed and transparent to improve understanding in the investor community. **Furthermore, the EIF should play a part in lowering institutional reluctance to invest in early-stage funds by providing the proper signals to the market. Given its resources, expertise, market standing, mission and longer-term horizon, it should be able to act counter-cyclically while improving, not weakening, commercial confidence. The EIF should therefore take the lead by committing to investment in new funds being raised by existing**

teams. It should also enable venture capital fund-raising teams to attract a wider range of investors by putting flexible downside protection arrangements in place.

Business angel activity in Europe for R&D intensive start-ups at the seed stage is still weak in comparison with the US. Member States and regions differ markedly in the extent and professionalism of business angel activity. To remedy this, **national measures such as fiscal incentives or co-investment programmes should be introduced to liberate market mechanisms, and angel syndicates, like VC funds, should be eligible for national tax benefit schemes and national and EU leverage schemes. Member States should also undertake national publicity measures to highlight the potential of business angel activity, and the Commission should consider making funding available to and through the European Business Angel Network to publicise angel activity**.

Demand as well as supply constraints need to be addressed. The problem of availability of risk capital for the commercialisation of R&D is not just one of supply. SMEs and potential start-ups need more education and advice on the availability and appropriateness of external risk capital. **The Commission and Member States should consider making public resources available to improve awareness concerning the appropriate application of risk capital. Any such activity should complement and build on existing initiatives in the Sixth Framework Programme and elsewhere.**

6.3.4 Equity and Loan Guarantee Measures

Guarantee Mechanisms come into play when the public sector tries to increase R&D investment levels by offering to share part of the risk borne by financial institutions when supplying capital for R&D and innovation related activities. Typically these take the form of either Equity Guarantees or Loan Guarantees. The former are appropriate for NTBFs and R&D-intensive SMEs. The latter are best targeted at established SMEs undertaking limited risk R&D projects. They both have a valuable role to play in the establishment of venture capital markets and the stimulation of high-tech, research-intensive SME activity.

Key messages concerning the utilisation of Guarantee Measures are as follows:

EU Member States without a developed venture capital industry, particularly those without 'early stage' venture capital firms focusing on the provision of seed and start-up capital, should consider introducing an equity guarantee programme for a limited period of time. There have already been programmes in a number of Member States that have successfully supported the entry of new venture capital firms, and these programmes provide a wealth of experience, for example, in the use of innovative option-based pricing for guarantee premiums. **The EIF could help support these developments by providing counter-guarantees for new programmes and by taking the initiative in promoting a pan-European technology rating system**.

Horizontal loan guarantee schemes, i.e. schemes applicable to a broad spectrum of SMEs, are more appropriate for achieving goals such as job creation rather than for the promotion of R&D spending. Guarantees in these schemes apply almost exclusively to bank loans, and most banks are not equipped to judge the risks of R&D investment. However, some Member States, Germany in particular, have had success with innovation loan guarantee programmes which have mechanisms for evaluating technological risk and are specifically meant to finance R&D projects in established SMEs. Support for such projects is less risky than financing start-ups, firstly because established SMEs tend to have a larger financial cushion for absorbing losses from failed projects, and secondly because R&D projects undertaken by established SMEs are typically incremental improvements of existing products and services which themselves involve low levels of risk. **Member States without a targeted innovation loan guarantee scheme should consider the establishment of such a programme. These developments could be supported by the EIF through the establishment of a counter-guarantee scheme specifically for national and regional innovation loan guarantee programmes.**

The flow of finance to innovating SMEs, and perhaps to larger firms as well, could be usefully stimulated via the broader use of innovative financial practices and products. One such product that has already been used in Germany is the securitisation of SME loan pools – pools that typically include some loans for R&D and innovation. **Member States should consider establishing new agencies or development banks, or broadening the remit of existing agencies or development banks, to include loan securitisation. The EIF should support this development by participating in securitisation, as it already has done a number of times with Germany's KfW**. Other products, which have not yet been widely used, but which, in principle, could support R&D finance, are insurance products that insure companies against the risk of failed R&D projects. Since these are products primarily offered by the private sector, **the European Commission could best support them by monitoring their use in member States and elsewhere and by encouraging a discussion on the merits of these financial instruments**.

6.4 Combining Policies

As noted earlier, there is no one combination of instruments that is applicable in all contexts. There are some guidelines, however, which deserve consideration whenever different combinations are considered.

6.4.1 National Policy Combinations

The wide diversity of national policy mixes in support of industry-oriented R&D and innovation schemes demonstrates both the range of problems faced by different nations and the various approaches it is possible to take in their resolution. That said, support for R&D projects within single firms is by far the most common policy objective and tax incentives a popular way of delivering support of this nature. Other policy objectives and delivery mechanisms are in evidence on a frequent basis in most of the larger economies, but less frequently so in smaller economies. Integrated packages of policy mechanisms are also gaining in popularity. **Whereas Member States can learn much from other countries about the relative efficacy of individual policy mechanisms, the precise nature of a policy mix suitable to their own circumstances will depend crucially upon the complexity of their own innovation systems and their associated strengths and weaknesses**.

6.4.2 Policy Mixes for Stimulating R&D Investment

There are a limited number of roads to increased R&D investment but many ways of travelling along them. In the short term, the route likely to lead to the most dramatic increases in R&D involves making the EU an attractive place for R&D-intensive MNCs to grow or relocate R&D capacity. R&D is also likely to be considerably enhanced in the longer term by efforts to create a favourable environment for the creation and support of dynamic, R&D-intensive SMEs in new and existing high-technology areas with a high potential for growth. Other routes include boosting R&D activities within existing moderately R&D-intensive firms, and expanding the R&D community by enabling non-R&D performers to enter the fold. For each of these routes there are a wide variety of policy mechanisms that can be deployed, with the policy mix for each route having a different composition and focus, though each involves a very broad mix of financial and fiscal measures combined with policies that affect framework conditions. For the routes involving the creation of new R&D intensive SMEs and the initiation of R&D activities in non-R&D performers, catalytic risk capital and guarantee instruments and measures supporting information exchange and networking are very important policy foci. In contrast, direct measures such as support for R&D projects and public technology procurement combine with indirect fiscal measures to form a critical policy focus for increasing existing R&D investment. In terms of attracting MNCs, however, policies affecting a few key framework conditions are more important than most financial and fiscal measures.

The particular routes and policy mixes prioritised and chosen by public authorities will ultimately depend on local circumstances. If it is necessary to travel along all routes, however, the combined policy mix will invariably have to contain an extremely rich mix of both financial and fiscal measures and policies affecting framework conditions.

6.4.3 Focused Policy Combinations

Any attempt to construct combinations of financial and fiscal policy instruments, either in Focused Policy combinations or in conjunction with other policy instruments affecting framework conditions in Holistic Policy combinations, should begin with a review of their use in isolation. This should compare items such as their specificity, e.g. the pros and cons of their use in different circumstances, and estimates of their potential impact and importance. Potential interactions with other instruments should also be examined.

Direct and Indirect Fiscal Measures form natural complements in a policy portfolio if the overall aim is to raise R&D investment levels along both a broad front (by using Indirect Fiscal Measures) and in specific areas of strategic interest (via Direct Measures). A careful balance has to be maintained, however, in order to ensure that high tax incentives for R&D in general do not lower the attractiveness of Direct Measures intended to reorient existing technological trajectories by focusing on particular technology areas. **In the context of the EU, given that the Commission is not in a position to initiate tax incentive regimes but is in a position to increase funding for Direct Measures, Member States should consider the latter as complements to both national Direct Measures and indigenous R&D tax incentives**.

Guarantee and Risk Capital Measures are also natural complements. The former, especially equity guarantee measures, have a critical role to play in the establishment of venture capital markets. The latter are particularly useful once these have been established and there is an increased need for other risk-sharing mechanisms if market distortion is to be avoided. **Member States with immature venture capital markets are urged to consider the phased application of Equity Guarantee and then Risk Capital Measures**.

There has to be an interface between Direct Measures and Risk Capital Measures. For firms the innovation process is seamless. For public authorities, the provision of support is often segmented. **Policies spanning the gap between R&D and its exploitation need to be part of in integrated portfolio of support policies if individual firms are fully to appreciate and benefit from the support on offer.**

6.4.4 Holistic Policy Combinations

Cluster Policies and Technology Platforms are important examples of attempts to develop systemic or holistic policies. Both involve the use of a systems approach to pinpoint problems and potential solutions and both foresee the need to construct solutions composed of combinations of policy instruments. Both also necessitate the involvement of multiple stakeholders in the formulation and implementation of the resultant policies and activities.

Technology Platforms are particularly relevant to the task of raising R&D investment levels because of their critical contribution to the development of new lead markets in areas such as biotechnology, nanotechnology and the hydrogen economy. Efforts by the European Commission to establish Technology Platforms for the discussion, formulation and implementation of policy options in these areas should therefore be encouraged.

Cluster policies can be developed at regional, national or international levels to rectify deficiencies in innovation systems and strengthen the interactions between the innovation actors involved. Cluster policies at national and international levels should include elements tackling the framework conditions affecting R&D investment levels, whereas those formulated at a regional level should prioritise the use of financial and fiscal measures.

6.4.5 Delivery, Coordination and Governance Issues

Multiple policy instruments can confuse target audiences. Complex policy mixes aimed at raising private sector R&D levels need to be carefully packaged and presented. **Delivery systems need to be streamlined and advice offered to intended beneficiaries on the relevance of different options to their needs**.

There should be few concerns about State Aid rules being abused by individual firms taking advantage of multiple instruments within the context of complex policy packages. Some abuse will undoubtedly occur, but the likely costs are outweighed by the potential benefits and do not warrant heavy monitoring and policing systems.

The formulation and implementation of appropriate policy mixes often involves separate government departments, and it is vital that

adequate mechanisms are in place to ensure coordination and coherence. At a national level, inter-departmental committees chaired by Heads of State are warranted given that the 3% target was set by the European Council.

The regional dimension of R&D and innovation policy is becoming much more important. To ensure that policies relevant to the needs of individual regions are formulated and that the routes taken are also in the collective interest of both parent Member States and the EU as a whole, **coordination between the various levels of governance will need to be strengthened**. The European Commission should also facilitate the exchange of relevant experiences and policy lessons across both countries and regions.

The adoption of the 3% target may call for trade-offs between policies in different spheres. Public expenditure on policy mixes aimed at increasing private sector R&D investment could come under pressure if there are competing claims on public budgets. To counter this, **public sector bodies should consider further actions to promote the public understanding of science in general and the relevance of R&D to economic growth in particular**.

6.4.6 Strategic Intelligence

Policy mixes cannot be formulated in a vacuum. Concerted efforts are needed to improve the strategic intelligence upon which policy formulation is based. In particular, better data are required on R&D intensity levels at different levels of aggregation across the EU; the scope and scale of evaluation systems and practices need to be improved within Member States and procedures put in place to share the results; a link between benchmarking exercises and the proposed Open Method of Coordination would benefit both policymaking and the practice and utility of benchmarking exercises; and foresight exercises are needed not only to identify technology hot-spots, but also to involve stakeholders in the formulation of desirable and achievable policy agendas and action plans.

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SUMMARY

The European Council in Barcelona set an overall EU R&D investment target of 3% of GDP by the year 2010, with industry asked to contribute two thirds of this figure. To approach these levels, however, dramatic improvements are needed in the effectiveness of policies used to stimulate private sector R&D. The specific aim of this report, therefore, is to offer suggestions and guidance concerning the construction of policy mixes capable of raising private sector R&D intensity in the EU to the required levels. The report considers the range of policy instruments available to tackle the problem of the R&D investment gap, focusing in particular on financial and fiscal instruments but also covering a range of other policies affecting the framework conditions for R&D and innovation in the EU. After reviewing the use of these instruments, both in isolation and combined in a variety of policy packages or mixes, the report then presents a series of recommendations for the consideration of policymakers across the EU.