Annex D: Economic incentives to business R&D

Table of contents

Economic incentives to business R&D

1. What is the rationale for public intervention?

The traditional approach

1. The traditional justification for public funding to business R&D is based on the presence of market failures in the production and dissemination of knowledge. These failures are thought to prevent the Pareto efficient allocation of R&D resources through market forces and to undermine private incentives to invest in R&D. Three main market failures relevant to the provision of R&D are usually identified: externalities, uncertainty and indivisibilities.

2. Externalities in the generation of knowledge are related to the problem of appropriability of research results. If firms cannot fully capitalise the value of their discoveries and prevent competitors or users from benefiting from spillovers, they will invest in R&D less than would be socially optimal. Another source of market failure is related to uncertainty and risk: in the case of a research project, an additional layer of "technological uncertainty" (how to make a new product/process) is added to the usual problem of "market uncertainty" (how to ensure its commercial success)[1]. Uncertainty is to a large extent embedded in the nature of innovation, which relies on the exploitation and generation of information asymmetries. However, risk perceptions may lead to under-investment in R&D compared to the socially optimum level and in particular constrain firms' access to external financing[2]. Third and finally, R&D is typically characterised by indivisibilities and economies of scale that create strong incentives for firms to monopolise markets.

3. Economists generally agree that, on balance, market failures will lead market mechanisms to fail to provide the socially optimal *level* and *direction* of R&D activity[3]. Projects with large benefits for the society or that may help to meet important public needs may be turned down because of their low perceived private returns and excessive risks. Indeed, econometric studies have shown that social rates of returns to R&D are several times larger than private ones[4]. Public support thus is justified to restore the socially desirable level of business R&D.

4. On these premises, the failures in the market for R&D can be addressed either *directly* (i.e. by targeting them at their source) or by influencing the *incentives* of private players, to undertake the socially desirable level and type of R&D activities[5]. Within the first group of measures, granting the inventor a temporary monopoly through intellectual property right protection may address the problems of appropriability of research results. However,

[1] To these, Geroski adds a third source of uncertainty : competitive uncertainty whereby the firm needs to be the first on the market

[2] Problems of information asymmetry lead to an inefficient functioning of the capital markets for innovation, implying that firms are, to a large extent, bound to fund R&D from internally-generated sources.

[3] Economic theory points to 2 factors going in the opposite direction and promoting over-investment in R&D : distorted incentives linked to patent races and the transfer of rents through creative destruction. On balance however a decentralised market economy will under-invest in R&D (Jones and Williams 1999).

[4] Griliches (1992). More recent empirical studies on the evidence of spillovers are quoted in Klette, Moen and Griliches (1999).

[5] In both cases it is assumed that the policy maker is a fully-informed social planner who can identify and implement optima.

intellectual property rights may not be sufficient to exclude imitators[6]. They also have a social cost in terms of restricting the diffusion of technological improvements. As for the disincentives related to the risk and uncertainty of R&D investments, they would require the existence of markets to shift risks. The very information asymmetries associated with R&D[7] activities however imply that such markets will not operate efficiently.

5. Alternatively, or as a complement to the above measures, the government may seek to influence business *incentives* to invest in R&D. A subsidy modifies private incentives to engage in R&D by raising the expected returns of innovation and narrowing the gap between private and social returns. It also allows to overcome some of the constraints on external financing caused by risk and uncertainty perceptions. We will deal extensively with subsidy-based instruments in later paragraphs.

6. Whichever the approach taken, the traditional approach holds that "pure markets" will not be efficient in stimulating innovation due to the characteristics inherent to R&D. Some form of government intervention thus becomes justified. Even is this were accepted, the subsequent decision on which instrument to adopt, which organisations should benefit and by how much is not trivial. It requires a detailed knowledge of the likely impact and the relative effectiveness of various instruments, including possible undesirable side effects of public intervention.

Some useful definitions

7. Before moving to the most recent theories on R&D and their policy implications, it is useful to define some of the most widely used concepts in R&D and innovation policy. R&D is defined as "creative work undertaken on a systematic basis in order to increase the stock of knowledge (..) and the use of this stock of knowledge to devise new applications" (OECD 1994). The term R&D covers three activities: basic research, applied research and experimental development.

8. R&D is only one activity contributing to the process of innovation. Innovation concerns the broader process of creating and improving products and processes, involving a series of scientific, technological, organisational, financial and commercial activities. R&D is only one of these, and may be carried out at different phases of the innovation process: while the "linear model" used to place R&D at the beginning of the innovation process, thought of as proceeding in a linear fashion (from research to invention, innovation, and finally diffusion of new techniques)[8] more recent models of innovation[9] see R&D as increasing the firm's stock of knowledge in all phases of the innovation process.

9. R&D is thus a necessary but not sufficient condition for the successful commercial launch of new products or processes. Linking R&D to innovation requires accounting for an additional set of institutional, organisational and economic factors. The "European paradox", whereby the EU seems to be failing to convert its strong scientific performance into strong technological and economic performances, provides evidence on the importance of such

[6] The ability to use IPRs depends on the extent the underlying information can effectively be codified. Also, the very act of patenting makes the information to be protected more transparent.
[7] Leading to moral hazard and adverse selection processes.
[8] A parallel process would be the progression from basic research, to technical knowledge, and practical engineering.
[9] Such as the « chain-link model »Proposed by Kaline and Rosenberg and used in the OECD Oslo Manual of innovation

factors. Policy makers are aware of the need to broaden the scope of their action, from pure R&D policies to policies in support of innovation.

10. *Basic (or pure) research* consists of experimental or theoretical work undertaken to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. The results of basic research are not generally sold but are usually published in scientific journals or circulated to interested colleagues. In contrast to basic research, *applied (or industrial) research* is an original investigation directed towards a specific practical aim or objective. Typically, it aims to acquire new knowledge that may be useful in developing or improving products, processes or services. The knowledge or information derived from applied research it is often patented but may also be kept secret. Finally, *experimental (or pre-competitive) development* is a systematic work, drawing on existing knowledge gained from research and/or practical experience, directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed (OECD 1994). Possibly the greatest source of difficulty in measuring R&D is locating the cut-off point between experimental development and pre-production developments, such as the production of user demonstration models and testing[10].

Market failures revisited

11. The actual size of market failures in R&D and their impact on business incentives may not be as clear-cut as suggested by the traditional view. First, their importance is not the same across industrial sectors and technologies, as these vary in their level of risk and the possibility to appropriate research results. Second, market failures do not affect all types of R&D to the same extent. They are the largest in the case of basic research, devoted to the acquisition of new knowledge without any particular commercial application. Indeed, businesses do not typically get involved in basic research, which remains the primary domain of universities, government laboratories and other publicly supported structures. Market failures and their impact on private incentives to undertake R&D are thought to be less critical the closer research is to the market. Public support to R&D offered in most countries is therefore structured in such as way as to be less generous to firms the closer R&D is to the commercial use[11].

12. A third issue to consider is that research results are not pure public goods, but involve transmission and reception costs. Innovators can to some extent improve the appropriability of their R&D by increasing the access costs to their discoveries. For example they may try to monopolise the supply of an asset that must be used in conjunction with the research result, or embody the new discovery in an output sold as a new product or process, or make the information traded very user-specific. Firms may also to some extent internalise knowledge spillovers through market contracts governing the flow of knowledge or by entering in R&D co-operative agreements. Tacit knowledge also mitigates the problems of limited appropriability: knowledge and information embodied in people and organisations do not

[10] The basic rule of the US National Science Foundation (NSF) is generally employed in difficult cases whereby "If the primary objective is to make further technical improvements on the product or process, then the work comes within the definition of R&D. If, on the other hand, the product, process or approach is substantially set and the primary objective is to develop markets, to do pre-production planning, or to get a production or control system working smoothly, then the work is no longer R&D."

[11] State aid pursuing allocative efficiency objectives should indeed be proportional to the magnitude of the market failure targeted, as measured by the marginal welfare loss It is also considered that the distortions entailed by government intervention will be larger the closer R&D is to commercial application.

spill-over perfectly and can be shared only through interaction and co-operation[12]. The institutional context in which this exchange takes place crucially affects the extent to which knowledge is actually diffused.

13. Fourth, externalities do not necessarily undermine private incentives to invest in R&D. As firms must typically undertake their own R&D to understand and free-ride on others' research results, externalities may actually trigger an increase in the total involvement in R&D. The net effect of knowledge spillovers on total R&D expenditures is thus not necessarily negative[13]. An additional consideration is that, in an oligopolistic setting, R&D expenditure is a strategic variable, which can be used to raise rivals' costs or barriers to entry. This may lead to excessive spending on R&D in some industries.

14. The other main market failure justifying public intervention in R&D relates to risk and uncertainty. Asymmetric information between borrowers and lenders about the project's future cash flows (leading to problems of adverse selection) and incentive and monitoring difficulties (leading to moral hazard problems) are expected to lead to under-provision of funds for R&D. Such problems of information asymmetries can to some extent be addressed through the capital structure of the firm (Goodacre and Tonks 1995). Firms may for instance signal the quality of their R&D projects by choosing a capital structure involving a large share of debt[14]. Debt also allows to mitigate the problems related to monitoring and moral hazard, as lenders will only need to monitor the borrower in case of insolvency. Similarly, a firm may signal the quality of its R&D investments and general creditworthiness by using only small proportions of external finance. The presence of liquid stock markets also provides a disciplining and monitoring mechanism through the possibility of takeovers, preventing the management from taking decisions (including on R&D projects) that do not maximise the investors' wealth.

The new perspective of innovation

15. The traditional approach to R&D and its policy implications has been heavily criticised by a growing body of literature supporting the emergence of a new economic perspective of innovation[15]. In contrast with the rather limited traditional approach focusing on R&D, the more recent theories consider the wider determinants of firms' ability to innovate. These theories stress the systemic and institutional aspects of innovation. The "National systems of innovation" approach and the more recent concept of "National innovative capacity" (Stern, Porter and Furman 2000) emphasise the wider conditions, regulations and policies within which innovation markets operate – and hence the inescapable role of governments in monitoring and improving this overall framework.

16. The new approach also emphasises the variety of learning processes of firms. Internal learning organised around formal R&D programmes is only one of these. Other important

---

[12] Tacit knowledge cannot be traded as a commodity due to limits to the capacity to codify it.

[13] This scenario may support an "infant industry" justification for government intervention: in an emerging industry or new technology, the lack of sufficient spillover effects may trap firms in excessively low levels of R&D, not allowing the emerging industry to reach the critical mass needed to take off. The government may therefore intervene to promote higher R&D activity until the industry reaches a high and mutually reinforcing R&D activity-level.

[14] Indeed a firm will be able to sustain a large debt overhang only is it expects to generate sufficient profits to repay the loans.

[15] Several « schools » have contributed to the development of this new theoretical paradigm: among others, those focusing on evolutionary economics, institutional economics, new regional economics, economics of innovation and economics of learning and knowledge.

types of learning are learning by doing and learning through interaction with external sources of knowledge. A successful innovator needs to learn not only about the specific technology but also about the market and users' needs. Innovation is driven by the diversity of firms, in terms of behaviour, knowledge and ability to learn. The focus of the policy maker becomes enhancing the diversity of learning mechanisms and promoting variety and experimentation, rather than focusing on individual research projects.

17. In such a perspective, the traditional concepts of market failure give little help in providing policy guidance as almost all aspects of knowledge creation and learning are characterised by market failures. The very development of new knowledge relies on the establishment of information asymmetries and different attitudes to risk[16] (Metcalfe 1995). At the same time, other typologies of market failures not strictly related to the properties of scientific knowledge are also identified as relevant to analysing the technological performance of a given system[17].

18. This new theoretical background calls policy-makers to take on new tasks and roles. Issues of "system failure"[18] become relevant along with the traditional "in-built" market failures of R&D markets. The scope for government action is broadened to become as much an issue of institutional design, inter-connectivity and firms' ability to learn as it is a question of subsidy.

Changing patterns of business R&D

19. Recent decades have witnessed considerable changes in the pattern of R&D. The rationale for some forms of government support may have become weaker, while new forms of government intervention and financing may now be more relevant and effective to stimulate innovation. According to the OECD (2001), the following main factors should be taken into account when re-assessing the scope for public intervention:

- *The transition to the knowledge-based economy:* knowledge has become a pervasive feature in developed economies, both as an input to production processes and as a factor embedded in new products, processes and services. The growing importance of the generation of knowledge argues in favour of an increase in the total levels of R&D investment. In countries with particularly low levels of business R&D, public support may thus be justified.

- *Restructuring business R&D*: increased competition and shortened technology cycles put firms under pressure to see quick and large private returns from R&D. Firms re-organise their R&D operations to make them more efficient and closely related to their corporate objectives, with priority being given to directly applicable research. This trend raises the prospect of under-investment in longer-term, speculative research, needed to support future innovation and with potentially large externalities and social returns. In some industries, however, the opposite may happen: for instance, the presence of network externalities (where the winner would take-all or most of the market) may actually stimulate investment

[16] It can be said that information asymmetries are a necessary condition for any technical change to occur, and in turn the new knowledge creates new sources of information asymmetry.
[17] Malerba for instance refers to 5 typologies of failures : learning failures, exploitation-exploration trade offs, variety-selection trade offs, appropriability traps and complementarities failures. Smith developed 3 types of failures : failures in the provision of infrastructure, transition failures and lock-in failures.
[18] These aspects of public policy can be examined via questions on firms' perceptions of obstacles to innovation.

in fundamental, ground-breaking research that could lead to new products, services or technologies, ahead of competitors.

▪ *Increased specialisation and linkages*: as R&D becomes increasingly costly, complex and risky, firms become more specialised and rely more on co-operation with other R&D performing organisations to share costs, supplement their internal R&D and reduce uncertainty. Networking and inter-firm co-operation are increasingly common and allow the diffusion of knowledge within the economy and across national borders.

▪ *An enhanced role of SMEs*: SMEs are increasingly active players in the R&D activities, also thanks to the removal of some of the main obstacles to their financing (at least in some sectors, smaller firms have benefited from the development of venture capital[19]). Innovating SMEs often have their origins in the academic world, and may play a mediating role between the generation of knowledge in universities and the exploitation by large firms. This also suggests that funding to universities remains a crucial element in fostering innovation by the business sector.

Redefining the scope for government intervention and emerging policy issues

20. R&D is thus becoming more competitive, market driven and widespread across the economy. In some industries there are indications of the formation of "technology market places" where firms create, buy and sell technology. The role of the government needs to be reconsidered in light of these developments to identify remaining market failures in private sector R&D. For instance, government support may have become less essential for R&D aimed at commercial applications, and rather ought to focus on encouraging fundamental research.

21. The OECD (2001) supports a continued and pronounced government role in promoting fundamental research, which yields large social benefits and for which "traditional" market failures linked to appropriability, risk and uncertainty are largest. Complementing private R&D, public support to R&D should focus on expanding the opportunities for innovation and establishing the basis for long-term new knowledge. The policy maker also needs to reconsider the way it distributes resources across the various players contributing to R&D. For instance, if the business sector tends to focus on applied research and experimental development and relies on external sources for the supply of basic knowledge and skilled human resources, then public financing of research by universities and public laboratories becomes particularly critical. This mutually reinforcing relation also works in the opposite direction, as public research tends to be most effective when associated to high levels of business R&D. Therefore in countries where the level of private R&D investment is particularly low, promoting business R&D as well as supporting longer-term generation of knowledge[20] would be justified.

22. Another policy issue concerns the allocation of public funds to different research areas: should the government support private research in emerging fields where the private sector is active and with clear ties to economic performance (i.e. ICT and biotechnologies)? Or rather maintain a certain degree of diversity in research portfolios to possibly allow for unrelated

[19] Venture capital does not support R&D per se but many recipients are highly R&D intensive small, growing companies. The development of venture capital implies that the government should reconsider its role in supporting innovating SMEs in order not to crowd out private investment[19]. Specific programmes for SMEs may have become less necessary, unless other market failures exist in the venture capital market.

[20] The question then becomes determining which level of private R&D should trigger such support.

discoveries which may lead to long-term breakthroughs? It is generally considered that the government is best placed to support diversity, while the business sector tends to pursue narrower strategies of exploitation of research[21]. However, narrower trajectories may sometimes allow to move rapidly ahead by exploiting incremental learning. The government may also have a role in supporting interdisciplinary research that addresses research problems from a variety of perspectives and requires a combination of diverse talents in their solution.

23. Another policy consideration is that the benefits from research are likely to spillover across national borders. If these effects are large, governments would be better off free-riding on other countries' pool of knowledge than financing domestic R&D[22]. Micro-economic evidence however suggests that, despite increasing economic openness and international flows of knowledge, spillover effects are stronger within countries than between them. An additional justification for supporting domestic R&D is that a certain level of research still needs to be undertaken domestically in order to be able to understand and use know-how and technologies developed elsewhere.

24. As we have seen the new theories of innovation have pointed out that R&D is only one element, albeit important, of the innovation process. The commercial success of a new discovery and its translation in improved growth and productivity levels depend on a complex set of inter-related factors, both internal and external to the firm (organisational, institutional, economic, etc.). If for some reason these are not in place or do not perform effectively, the firm will face difficulties in capitalising on its R&D efforts. A report by ETAN (1999) has suggested that support should also be provided beyond R&D, to "downstream" innovating activities[23] as these are often crucial for the commercial success of important technological inventions. However, the closer to the market public funds are granted, the larger the risks of distorting competition.

[21] This is sometimes referred to as the « exploration-exploitation trade off » (EC 1997)

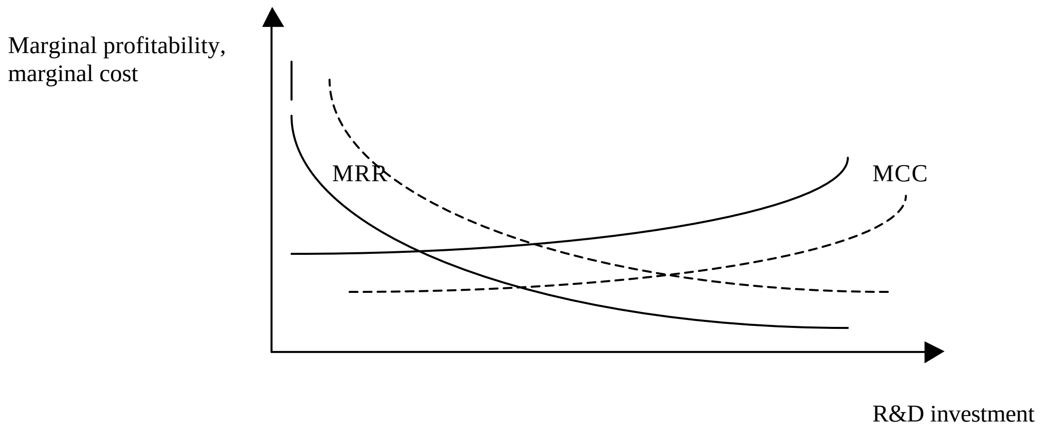
[22] Cross-border spillovers of knowledge also give scope for increased efficiency through R&D coordination between countries (this is one of the justifications for promoting R&D at the EU level).

[23] In the specific case covered by the report, support would be provided through tax credit schemes.

2. How should the government intervene?

Incentive-based R&D policies

25. The neo-classical approach of the firm as an optimising innovator assumes that each firm faces a number of potential R&D investment projects, rationally considers the expected costs and benefits of each of them and then chooses the profit maximising level of R&D expenditure equalising the marginal cost and the marginal profitability of research.



26. The MRR (marginal rate of return) schedule reflects the firms' innovation possibility frontier (i.e. the available technological opportunities), the state of demand and market competition, and all those institutional and other factors affecting the appropriability of R&D. Any change of the profitability of R&D will translate into shifts of the schedule. The MCC (marginal cost of capital) schedule reflects the opportunity cost of different levels of R&D investment. Its upward slope reflects the increasing dependence on external funds as the volume of R&D investment increases. The shape of the MCC depends on macro and microeconomic conditions affecting the cost of internal and external funds, including public policy measures that influence the private costs of R&D projects (including tax credits, R&D subsidies, cost-sharing programmes etc.) (David, Hall and Toole). A R&D subsidy, by relieving the firms of some of its R&D expenses, prompts a right-wards shift of the MCC schedule. In turn, the increased level of R&D leads to new innovations and higher profitability, translating in an outward shift of the MRR (indirect effect).

27. The key issue about subsidy-based incentive policies is that of additionality, i.e. ensuring that government spending does not crowd out but rather stimulates additional business R&D. If public funds are directed to projects that would have been undertaken anyway by the private sector, this would be a misallocation of resources. Viceversa, a complementary relationship between public and private research efforts would legitimise public funding. The main difficulty in ensuring additionality arises from asymmetric information, as the government does not know ex ante which projects are extra marginal

28. On a theoretical level, the leveraging effect of the subsidy on the beneficiary's R&D efforts will depend on the elasticity of its MRR and MCC schedules. Generally, the impact will be larger the flatter the MRR schedule. This will for instance be the case when diminishing returns to R&D appear relatively late with increased R&D expenditures, supply of inputs is elastic and the demand for the firm's products is large (Metcalfe 1995, David, Hall and Toole 1999). On the contrary, if the marginal profitability schedule is inelastic (i.e. vertical) then the firm will reduce its own research by the amount of the subsidy and crowding out will be complete. The policy maker should thus keep these elements in mind

when deciding which industries would react more to public incentives to R&D. Indeed, the impact of a subsidy will not be felt symmetrically throughout the population of firms and industrial sectors.

29. Some authors (David and Hall 1999) have also pointed to the possibility that R&D subsidies may induce some short-run crowding out if the market for the supply of R&D inputs is less than infinitely elastic. Increased demand for these inputs (notably skilled scientists and engineers) may displace some private R&D spending via an upward pressure on prices. In time however such increase in demand should stimulate larger supply of R&D inputs, moderating the pressures on prices. Another problem is that subsidies tied to R&D inputs but unrelated to R&D outputs may create moral hazard problems as firms may be encouraged to undertake second best R&D projects[24].

30. Already at a theoretical level it is thus difficult to say that R&D subsidies unambiguously stimulate additional business R&D, and that this would be of a high quality. Although the balance of the long-run dynamic effects seems to favour the emergence of complementarity rather than crowding out effects, the issue becomes an empirical one. In order to assess the likely incentive effect of the subsidy, the policy maker would for instance need to obtain reliable estimates of the elasticities of the underlying cost and revenue schedules. This would also imply that support would be differentiated according to which companies and sectors are being targeted.

A review of the main incentive-based instruments

31. Governments may influence the firms' incentives to engage in R&D and innovation through a variety of financial and fiscal measures[25]. These can be specifically targeted (e.g. to companies of a certain size, located in a particular region, active in a specific sector, etc.) or of general (indirect) nature. In most OECD countries the share of business R&D expenditures supported through direct instruments has decreased, with the government relying more on indirect forms of support that have a leveraging effect on private R&D (OECD 2001). The OECD points out that public support for business R&D involves a mix of direct instruments and market based incentives, as no single mechanism is able to provide a full range of incentives.

Direct instruments

32. **Direct subsidies** have the advantage of allowing the policy maker to retain control over the kind of research conducted, and direct it to those fields where the gap between private and social rates of return is the greatest and/or where risk and appropriability problems are largest. In theory, if these conditions were respected, then direct R&D subsidies would not displace real private R&D investment (except through the generic impact on input prices if these are in inelastic supply). In practice however the policy maker would be under pressures to subsidise projects with high private rates of return, entailing crowding-out effects. Another difficulty with the use of direct instruments is that the government retains a certain discretion as to the choice of the beneficiaries of its support.

---

[24] A less distortionary alternative to R&D subsidies may be the setting up a privately funded levy/grant system. Under the scheme, all firms of an industry contribute to the fund which then redistributes the resources as a subsidy to those companies which undertake more R&D as a compensation for the spillovers they generate for others.

[25] The for instance include depreciation allowances, deductibility of R&D expenditures and tax credits.

33. Another type of direct instrument to promote R&D is a public **R&D contract**, whereby the government procures a specific research needed to fulfil its mission. This instrument is typically used in the aerospace and defence sectors. The advantage of public procurement is that it allows to address some of the problems of incomplete appropriability by creating a market for firms' research output (Geroski 1995). It also addresses the risk problem by providing a certain commercial return on R&D investments. Within the neo-classical framework, a public contract translates into an outward shift of the MRR schedule by signalling future demand and thus increasing the expected profitability of research. If, thanks to the contract, the firm can sustain high fixed R&D start-up costs, the MCC schedule is also affected. However, additional factors may counterbalance this leveraging effect on total private R&D: crowding-out may occur in so far as the firms which have obtained the contract may not need any longer to invest in R&D in order to bid successfully for government procurement. Also, firms which have not received the contract may be put off from carrying out R&D since they would be at disadvantage compared to government contractors.

Indirect measures

34. Indirect measures include all schemes that promote business R&D without being targeted to a particular scientific or technological theme or sector. **R&D tax incentives** are among the most commonly used indirect instruments[26]. Tax incentives are considered attractive market-based mechanisms that leave to market forces the allocation of public support across industrial sectors and individual firms. They also allow a faster reallocation of resources in response to technological development, and allow firms to estimate available public support ahead of undertaking an investment. Tax incentives are also thought to entail lower problems of moral hazard compared to direct subsidies. Indeed, companies are encouraged to propose projects with good chances of success as they need to make a profits in order to benefit from the tax credit. Another attractive feature is their supposedly low administrative costs for government agencies[27]. Fiscal incentives can also be used to promote research policy goals. In this regard, they can reinforce joint public-private research efforts, an area where Europe still lags behind other parts of the world. They can also direct investment to areas which are in the public interest.

35. Despite these advantages, tax credits also display some less desirable features. There are indications (OECD 2001 and ETAN 1999) that they are not successful in truly influencing corporate R&D strategies, but rather reward those firms which already undertake R&D investments (i.e. they increase private R&D at the margin). Also, while there appears to be no crowding out of nominal private R&D expenditures[28], tax incentives affect the composition of R&D investments. To take advantage of the tax credits, firms will concentrate on projects that will generate greater profits in the short-run. Projects with high social rates of return and long-term exploratory projects would be relatively penalised. This weakness can be alleviated by adopting differentiated levels of tax incentives to favour socially desirable investment projects.

36. While leaving firms free to decide how best maximise the tax relief themselves, another common criticism is that tax measures give government little control on the kind or quality

[26] The European Commission has launched a benchmarking exercise on the use of fiscal incentives to promote business R&D and innovation, in order to identify world-wide good practices for policy development.

[27] Administrative costs may in reality be higher than it appears at first sight. The main difficulties arise from the definition of eligible R&D expenditures and the classification of R&D performed by subcontractors.

[28] See below on the empirical evidence on the effectiveness of tax incentives for R&D.

of R&D performed. On the one hand, if the aim of public intervention is to support a particularly risky project, or a project with a large gap between private and social valuations of R&D, it might be more efficient to target it with direct measures. On the other, indirect measures make it more difficult to exclude from the incentive scheme R&D possibly contrary to public policy objectives (such as health or safety). Also, tax incentives will in reality still discriminate among beneficiaries because they will have different effects on companies (for instance some firms may not be able to use the full value of the tax credit if they lack sufficient taxable profits). Other drawbacks of using fiscal incentives are the changes introduced in the tax environment and consequent loss of transparency and certainty[29].

37. **Personnel-based schemes** have also be suggested to stimulate R&D activity, as they allow to reduce the costs of hiring skilled personnel, which account for the a large share of total research expenditures. These schemes have the additional advantage of promoting higher levels of employment, easing the entry in the labour market of new graduates and encouraging the introduction of skilled personnel in SMEs, often unfamiliar with employing scientifically trained staff. Personnel-based instruments may take the form of grants or loans for graduate staff, or can be linked to tax credit schemes.

38. According to the European Technology-Policy Assessment Network (ETAN), R&D incentives applied to payroll taxes may even be superior to incentives applied to corporate income tax (ETAN 1999). They contribute to improving the quality of the R&D activities, and not just their volume, because they foster the inflow of new fresh competencies into companies. Personnel-based schemes should also be easier to administer, as incentives would be based on new jobs created, saving the need to assess whether certain activities qualify as eligible R&D expenditures. ETAN also considers that they have a stronger incentive effect on companies which currently do not perform R&D compared to traditional tax-based measures. ETAN recommends that care should be given to the management and organisational aspects of these schemes, and that these should also be sufficiently stable and long-lived to allow firms to become familiar with their use.

Enhancing connectivity

39. An additional group of policy instruments includes all measures aimed at increasing the productivity of R&D by enhancing the external supply of knowledge and skills to firms and improving their interaction with the other parts of the national innovation system (Metcalfe 1995). In line with the new theories on innovation, this policy approach emphasises that while the policy maker may not have perfect foresight on the potential success of a R&D project, he probably enjoys a superior ability to co-ordinate different institutions. In order to do so, the policy maker needs to understand the way innovation systems operate, how institutions interact in it and how technical improvements occur. Successful co-operation needs to be appropriately designed and managed. The choice of partners, the determination of what is contributed and shared, the definition of the objectives and the modes of management are key elements in the success of the co-operation.

40. **Public-private partnership schemes** are frequently used to foster exchanges and technology transfers between business and public sector players involved in R&D. They entail joint sponsorship of R&D ,with participants providing funding or in-kind contributions (such as personnel, facilities, intellectual property). Besides the simple cumulation of

---

[29] Changes in other tax policies affect the tax wedge on R&D making it more difficult for firms to consider the effects of the incentives when making long-term investment plans.

resources, the largest benefit from private-public partnership programmes is that they encourage co-operation and networking between different R&D players. Such schemes promote private sector contribution to government R&D with significant social returns, and increase the opportunities for commercialisation of government research. Some of the difficulties associated to the use of public-private partnership schemes are the selection of the best projects from both a private and social perspective, and the need to strike a balance between the adequate diffusion of the publicly funded knowledge and ensuring that the private sector will be able to commercialise the result of the joint R&D.

41. **Tax incentives** can also be geared to improve the linkages between different parts of the innovation system and bridge the gap between research conducted in public research institutions and industry. Specific tax reductions could for instance be offered on business expenditure linked to collaborative industry-academia research projects. Tax incentives could also be used to encourage companies, particularly SMEs with little in-house R&D capacity, to outsource research projects to public research institutions.

Designing the best R&D policy mix

42. According to the OECD (2001), public support for business R&D requires a mix of direct instruments and market based incentives, as no single mechanism is able to provide a full range of incentives. For example, market-based mechanisms such as tax credits increase R&D at the margin, implying that more direct forms of support may be needed to stimulate more substantial R&D investments. Direct and indirect measures therefore need to be balanced in a comprehensive and co-ordinated policy framework. It is also crucial that both direct and particularly indirect instruments are sufficiently stable over time to be effective stimulants to private sector R&D[30]. Clarity and comprehensibility about the aims pursued by the incentives, and about their beneficiaries and eligibility criteria are also important to their effectiveness. Policy makers also need to ensure that the instruments put in place are sufficient flexible. In particular, it should be possible to shift R&D funds into areas of increasing economic importance and to guarantee a continuous match between the creation of knowledge and industry's ability to exploit it.

43. The OECD also notes that care should be taken as to the way different instruments interact. For instance, some studies have pointed out that increasing direct government subsidies to business R&D may reduce the effectiveness of tax incentives, while direct subsidies and research undertaken by public institutions appear to have a mutually reinforcing effect (the more firms invest in own R&D, the more they are able to use knowledge generated by public institutions) (Guellec and Van Pottelsberghe 2000). Such interactions between different policy instruments call for close co-operation between the various government bodies involved in their design and management. Generally speaking, a piecemeal approach to R&D policy is likely to be detrimental to its effectiveness.

[30] See below on the empirical evidence on the effectiveness of public incentives to R&D.

3. What is the empirical evidence on public incentives to business R&D?

Assessing the effectiveness of public incentives to R&D

44. Most economists agree on the theoretical desirability of public support to R&D, but acknowledge that there are large uncertainties about the actual size of R&D market failures and the net effects of public intervention. To provide empirical support to public intervention in this area it is therefore important to evaluate the economic benefits of R&D subsidies in order to assess their effectiveness and cost-efficiency. This should also allow for comparisons with alternative uses of public funds.

45. Despite the importance of the issue, available empirical evidence is relatively modest and not completely conclusive. Research on this topic has taken the form of either quantitative or qualititative studies[31] at different levels of investigation (line of business or laboratory, firm, industry or domestic economy). Ideally, evaluating the effectiveness of a R&D subsidy would involve comparing the social benefit from increased business R&D to the opportunity cost of using the public funds in another way. This however is a rather complex exercise, which would require detailed information on alternative uses of public funds and the benefits which are sacrificed in consequence. In the absence of this information, policy evaluation has usually taken the form of a simpler cost-benefit analysis.

46. Empirical studies have attempted to either find evidence of a leveraging effect of public over private R&D investment, or to measure the impact of public support on R&D profitability. An important issue when evaluating the impact of government sponsored projects is to estimate what would have happened without the subsidy, i.e. designing an appropriate counterfactual. This raises a number of methodological problems[32], which add to the need to employ a number of variables to "control" for external influences on companies' decisions and performance.

47. The typical cost-benefit analysis involves comparing the amount of incremental private R&D to the amount of the subsidy (or the loss in tax revenue). If the ratio between additional R&D and the subsidy is larger than one, then the subsidy is seen as a more cost-efficient way to achieve a certain level of R&D compared to direct public provision. The limit of this kind of cost-benefit analysis is that it is loosely connected with the magnitude of the underlying market failures. It implicitly assumes that the R&D support scheme has been set at the optimal level and is actually targeted to fields where externalities and/or uncertainty problems are large[33].

[31] Based on interviews or case studies

[32] There is for instance a selection problem. If only the most innovative companies receive public support, then the measurement of their performance would overestimate the impact of the public incentive. Also, non-supported firms may perform differ systematically from how supported firms would have performed in the absence of the supported scheme. Another issue is related to spillovers: if these are large (and this is among the reasons why the government wishes to intervene in the first place) then it becomes difficult to measure the impact of R&D incentives by comparing the perfomance of supported and non-supported firms.

[33] If the social return from additional private R&D is very high, one may be willing to give up more tax than the actual research induced by the subsidy. On the contrary, if the social return is only slightly higher than private ones, even if the incentive induces more private R&D it may not be a good idea because the funds could have been spent on activities with a higher social return. Fortunately the evidence on the social returns to R&D suggests that the first case is more likely (Hall and Reenen 1999).

The empirical evidence on additionality

48. Based on the research pioneered by Blank and Stigler in the 1950s a number of studies have investigated the relation between publicly funded and private R&D, testing for a complementary or substitutive relation. These studies focus on the critical issue of additionality, to assess whether public resources really stimulate additional private R&D investment activities or rather crowd out projects that business would have carried out anyway.

49. In their comprehensive survey of 33 empirical studies at different levels of aggregation, David, Hall and Toole (1999) evaluate evidence on the effects of public R&D grants and contracts on private R&D investment in the manufacturing sector. The authors show how different empirical studies arrive at different conclusions about the size and magnitude of the relationship between public and private R&D. Besides methodological and investigation problems[34], it is difficult to compare institutionally different subsidy programmes applied to diverse industries and technologies. The precise way in which R&D subsidies are administered is also an important determinant of their effectiveness. With these limitations in mind and based on an unweighted summary of the studies reviewed, the authors find that most econometric results tend to indicate a complementary relation between private and public R&D investments. However, in one third of the studies reviewed public R&D support is found to be a substitute for private R&D investment. This result is more prevalent in studies conducted at the level of business line and firm compared to studies carried out at higher levels of aggregation (industry and national economy).

An empirical study focusing at the level of *line of business* is the one by Klette and Møen (1998). The study reviews the effectiveness of a government matching grants programme for Norwegian IT firms. The study is one of the few to control for the potential endogeneity of receiving a grant that arises from firm self-selection into the programme. The authors find that government R&D support does not crowd out private spending but nor does it encourage additional company investment in R&D as should be expected by the matching grant scheme used. In the second part of their study, the authors introduce a structural model of R&D investment that incorporates a "learning by doing effect", whereby past R&D efforts have a positive impact on the productivity of current R&D. Under this more dynamic framework it is suggested that temporary R&D grants might have a more lasting, positive effect on private R&D spending after the support has expired, although the empirical results are not conclusive[35].

A recent empirical study by Lach (2000) on the impact of R&D subsidies at the *firm level* leads to similar results. The author reviews the effectiveness of a Israeli matching grant programme in support of business R&D[36]. The study indicates that in the short-run subsidies displace private R&D investment, but in the longer term this crowding out effect is compensated by an increase in private R&D investment. When introducing dynamic effects, public subsidies appear to stimulate additional private R&D expenditure. Quantitatively, the

[34] The various studies are conducted at different levels of aggregation (line of business, firm, industry, domestic economy, etc.) and cover various modes and purposes in government funding of R&D (grants, procurement contracts, cost-sharing arrangements, subsidised loans, publicly undertaken R&D, etc.)
[35] Klette, Møen and Griliches 1999
[36] The main source of grants is the programme administred by the Office of the Chief Scientist at the Ministry of Industry and Trade. Under the programme, R&D of all kinds may be sponsored on a project by project basis. Most subsidies are granted to cover 50% of the research costs, i.e. firms are committed to match the subsidy received. If the project is commercially successful, the firms pay back the subsidies in the form of royalties.

author estimates that the subsidy has a marginal effect of 0.41, i.e. an extra US$ of subsidy increases company-financed R&D by 41 cents in the long-run. Although positive, the subsidy effect is substantially lower than what would be expected under the matching scheme. According to the author, the reasons for this “less than full” effect are that the subsidies are sometimes granted to projects that would have been undertaken even without the subsidy, and that firms may adjust their R&D portfolio by closing or slowing non-subsidised projects once the subsidy is received.

A rather different picture emerges from the empirical analysis carried out by Duguet (2000). He finds that R&D subsidies have a neutral effect on private R&D spending, i.e. neither stimulate additional research nor crowd out private one. This effect holds both for firms having a low probability of receiving aid (typically SMEs and companies investing little in R&D) and for those which are most likely to be eligible for such support. According to the author, these results are not in contradiction with those reached by Lach who finds evidence of an incentive effect (albeit small and incomplete). Indeed the author points out that Lach’s analysis focuses on the incentive effects of a matching grant scheme, which by its nature is explicitly designed to induce additional private R&D.

Czarnitzki and Fier (2001) have focused on the service sector to evaluate the effects of R&D subsidies. They analyse the impact of the subsidy programme administered by the German Federal Ministry for Research and Education (BMBF) on innovative expenditure[37] by firms. Under the scheme, authorities finance a maximum of 50% of total R&D project costs. The authors find that public subsidies have a complementary and sustainable effect in stimulating private expenditure in innovative activities and that they continue to have an influence - albeit decreasing- also on future expenditures on innovation (1DM of public R&D subsidy induces 1,37DM of private investment in the following period, which falls to 1,26 DM after the second year). They also find that innovation activities enhance companies’ chances of success in applying for public R&D grants in the future.

Are R&D tax incentives effective?

50. Economists have been traditionally sceptical about the effectiveness of tax instruments as a way to induce additional private R&D, considering that a huge tax cut would be needed to generate the socially desirable level of spending. To test for this scepticism, during the last decade fiscal incentives to R&D have been the object of several empirical investigations. The most recent studies rely on the estimation of the elasticity of R&D investment to the cost of R&D. This is used to infer the response in terms of additional R&D investment induced by a reduction in the cost of R&D through a tax reduction.

A comprehensive assessment of the effectiveness of R&D tax credits is the cross-country study of nine OECD countries by Bloom, Griffith and Van Reenen (2000). The authors collect information on the countries’ tax system to calculate the cost of R&D investments and derive the pre-tax real rate of return on the marginal investment project needed to earn a minimum rate of return after tax. The advantage of a cross-country study is that it allows to disentangle the impact of the tax credit from other contemporaneous micro and macro-economic events.

[37] This includes R&D expenditure but also other kind of expenditures such as those related to the acquisition of external technology and know how, training, marketing of the new products etc.

The authors find that tax incentives are effective in increasing R&D intensity after controlling for demand, country specific and world macro-economic effects. Econometric analysis shows a low short-run elasticity of R&D to tax changes (-0,16) but a long-run elasticity of around –1 (i.e. over time, a 10% fall in the cost of R&D stimulates a 10% increase in R&D expenditure). Fiscal provisions therefore seem to matter in the long-run while the response to tax credits tends to be very small at the introduction of the scheme.

These results on the leverage effect of tax credits for R&D and their distribution over time are in line with those of earlier empirical studies (particularly using data from the USA), and which show an insignificant elasticity to R&D tax credits in the short run (1-3 years after their launch) and an elasticity around –1 in the long run (Hall and Van Reenen 1999)[38].

51. Empirical evidence thus indicates that R&D fiscal incentives matter in the long-run, while their effects tend to be relatively small at first. The low short-run responsiveness of R&D suggests that firms face high adjustment costs of investing in R&D. This may be explained by the long-term nature of many R&D projects and by the fact that a large share of R&D budgets is composed by the salaries of researchers. If adjustment costs for R&D investments are indeed high, it is important that tax-based schemes are stable and of a sufficiently long duration to allow companies to become familiar with their operation and integrate their value into longer-term R&D planning.

52. The design of tax incentives is also a crucial element for their effectiveness. For instance, tax credits limited to capital expenditures are likely to provide a relatively modest stimulus, as a large portion of R&D costs is made up by wages and salaries. The OECD suggests that R&D tax policy should include provisions for the deduction of all qualified R&D expenses in the year in which they are incurred. Still on design aspects; volume-based tax incentives (i.e. granted to any unit of R&D undertaken by the firm) entail larger dead-weight losses compared to tax credits over incremental R&D expenditures.

53. Tax incentives must also be sufficiently flexible to accommodate firms at different stages of development. For example, allowing firms without tax liability in a given year to carry forward deductions may be particularly important for start-ups and SMEs. More generally, to be effective R&D tax credits must be adapted to the overall tax and business environment within which they are granted. Indeed, other important tax factors, such as corporate taxes, property taxes, payroll takes also play an important role in company decisions to invest in R&D[39].

Are R&D tax incentives desirable?

54. While empirical evidence suggests that R&D tax incentives are effective in stimulating additional business R&D in the long-run, in order to be desirable a policy must also be cost-effective. A benefit-cost analysis entails comparing the expected amount of R&D induced by

[38] The authors compare their estimates of R&D price elasticity with those of previous studies using US micro data and which found a price elasticity of between –1 and –1,5 in the short-run and even higher in the long-run (Hall 1993). They explain that such studies are likely to have over-estimated the impact of the tax credit either due to a failure to properly control for endogeneity problems at the firm level or due problems of relabelling of what represents R&D.

[39] As taxation is only one of the factors that inform a business decision, it is essential to consider the specific environment and circumstances in which they are granted. This also means that probably there 's no « one best way » in fiscal incentives to R&D, and that it may not be appropriate to transpose fiscal incentive schemes from one country to another.

the tax credit with the estimated loss in tax revenues: if the ratio between these two figures is larger than one, the tax credit is a more effective way to achieve a given level of R&D compared to direct public provision.

55. The benefit-cost ratio of a particular tax incentive scheme is likely to be influenced to a large extent by the design characteristics of such a scheme. Volume-based tax credits (whereby a subsidy is granted for each unit of R&D undertaken by the firm) may be quite effective in stimulating R&D but also entail large dead-weight losses and high costs for the government. To avoid such problems, most R&D tax schemes are designed as to grant a credit over incremental R&D only. The crucial issue thus becomes that of defining an appropriate base level over which calculating the portion of R&D which should be considered incremental. Rolling-average bases may lead to limited, and possibly perversely negative, R&D incentives. Indeed, in a dynamic setting is the tax credit is calculated on the extra R&D over the previous period, firms will have an incentive to moderate their additional R&D spending as this will affect the possibility to take advantage of the scheme in a later period. Fixed-base R&D tax credits appear better suited to avoid the negative dynamic effects from the use of rolling base. Two possible options to define the fixed base are the use of fixed R&D level indexed for inflation and a sales-indexed base (where the firm can claim the tax credit when R&D investments represent a higher share of sales than in the year the base was fixed).

A recent study (Bloom, Griffith and Klemm 2001) shows that, for a given estimated price elasticity of R&D, the cost-effectiveness of a tax incentive scheme is influenced greatly by the design characteristics of the scheme. Consistent with empirical evidence, the authors consider a long-term elasticity of R&D of around –1. Based on a sample of British firms, they find that tax credits schemes using a sales-indexed fixed R&D base are particularly cost-effective (with a long-run ratio of additional R&D to loss of revenue of about 3). On the other hand, in the case of volume based credits and tax credits granted on R&D in excess of a rolling average base, the long-run additional R&D they stimulate does not fully cover the loss in taxed involved by the scheme.

56. Bloom, Griffith and Van Reenen (2000) point to several additional elements that should enter a benefit-cost analysis on the desirability of tax incentives to R&D. These include the administrative costs of managing and monitoring the credit scheme[40] and international spillover effects. In addition dead-weight losses should be incorporated in the analysis as mentioned in paragraph 55. The issue of international spillovers is particularly relevant for small open economies, for which a possibly large share of the benefits from additional R&D would accrue to other countries. In an extension of their model, the authors also mention the potential for tax rivalry between governments for the location of R&D investment. The evidence of some relocation in response to R&D tax incentives implies that governments may be tempted to strategically set their R&D incentives with the risk of potentially costly tax competition

Examples of R&D tax treatment

Several OECD countries allow companies to write off all current expenditure on R&D against their taxable profits in the year the expenditure is made.

[40] These may be substantial for both the firm and the scheme administrator where the scheme is poorly designed.

The **UK** goes further and allows companies to write off immediately all R&D capital expenditure, including plant and machinery and commercial buildings but excluding land and dwelling houses. In addition, SMEs have a more favourable regime for their current expenditure with a 50 per cent credit on most of their current spending, and where the company is tax exhausted the R&D losses can be surrendered for a payable tax credit.

Canada allows companies to write off R&D capital expenditure against profits immediately, with the exception of all buildings. Canada also has a tax credit that applies to current expenditure and that gives large companies a 20 per cent credit (35 per cent for SMEs). This credit has a payable element for SMEs and it is taxable.

France allows companies to write off R&D capital expenditure, excluding industrial buildings, in a straight line over five years. Industrial buildings are written off over 20 years. France also has a 50 per cent incremental tax credit for current expenditure, which is payable on all current expenditure above a moving average of the previous two years' expenditure. It is limited to a maximum payment of FF40 million.

Italy allows companies to write off R&D capital expenditure at an accelerated rate of 10 per cent. Italy has a tax credit for SMEs at 30 per cent on all current spending.

The **US** allows companies to write off most R&D capital expenditure over 3 years, although buildings are written off over 15 years. The US also has an incremental tax credit of 20 per cent on current spending, with the base defined by reference to previous ratios of R&D expenditure to sales. As in Canada, this credit is taxable.

Source: OECD and Revenue Canada

R&D incentives and company performance

57. We have so far been concerned with the effectiveness of public incentives in stimulating additional levels of business R&D expenditure. This does not shed much light on the way companies have performed as a result of the incentives, and particularly on the quality of their research output. If public incentives encourage moral hazard behaviour by firms and induce them to undertake second best or very risky projects, the rate of return of such spending may be very low although the additionality effect may be respected.

Adams, Chiang and Jensen (2000) examine the impact of the US Co-operative Research and Development Agreements (CRADAs) on business research performance. CRADAs are voluntary joint research contracts between federal government laboratories and private companies. Many of them involve cost-sharing whereby company and federal laboratory resources are matched, often on a one-to-one basis. Under the usual terms the private partner is allowed to retain the intellectual property that results from the joint research. The authors find that CRADAs are the most important means by which federal laboratories influence patenting and business financed R&D. Companies participating in a CRADA tend to file more patents and spend more on own-financed R&D. The authors emphasise the technology transfer aspects of these agreements more than the government funds involved. Important elements contributing to the success of CRADAs are the fact that they require the continuous effort on the part of both firms and government laboratories and that participants are free to choose with whom to co-operate.

Branstetter and Sakakibara (2000) look at the impact of Japanese government-sponsored research consortia on the productivity of participating firms in terms of patents. Their econometric results show that both participants and non-participants tend to increase their patenting activity after the inception of the consortium[41]. However, when including firm and consortium fixed effects, it appears that the marginal increase of participants' patenting is positive but rather small in size. The authors find that the effectiveness of the consortia on company performance is positively related to the potential for spillovers between firms, which depends on their technological proximity. R&D consortia focusing on fundamental research removed from commercialisation have the highest performance, while those set up between companies which are direct competitors on the final product market are less effective in promoting increased patents[42]. According to the authors, these design characteristics of consortia are much more important in explaining research outcomes than the level of public subsidies devoted to them.

Klette, Moen and Griliches (1999) have conducted a critical review of 4 micro-economic studies on the impact of government support to R&D to the manufacturing sector. One of them is the study by Irwin & Klenow (1996) on the performance of the US SEMATECH research consortium, where about half of the budget was financed by government subsidies. The authors find that the consortium was successful in eliminating excessive duplication of R&D, which was a major objective of the consortium. On average, firms participating in the consortium also displayed a faster growth in sales than non-member firms. However the authors did not find any systematic difference between members and non-members in terms of physical investments, returns on assets and sales and labour productivity. A major reservation about the results of this study concerns the validity of the control group of firms as the member firms were among the leading companies in their market already before the setting up the consortium.

A study reaching somewhat different conclusions is the one by Geroski, Samiei and Van Reenen (1996). They developed a dynamic econometric model of UK corporate patenting and innovation activity to simulate the likely effect of the introduction of R&D subsidies. The authors find the outcome in terms of company performance rather disappointing and conclude that the case for government intervention in promoting technological advance through incentive-based instruments is limited.

[41] The latter result can be interpreted as evidence of spillover of the results of consortia research over technologically related non-participants.

[42] As the gains in profits from participating in the consortium are likely to be offset by the improved performance of its rivals, each firm will set lower levels of R&D investment in the consortium, which will lead to a lower R&D output.

4. The Community Framework for state aid to R&D

The main inspiring principles

58. The EC Framework on state aid to R&D was adopted with the aim of striking the balance between, on one hand, the need to ensure fully competitive conditions within the Common Market and, on the other, the promotion of the long-term competitiveness of the European industry. The current Framework was adopted in 1996 and is due to be renewed in 2002. It provides for the possibility to exempt aid to R&D from the general prohibition of state aids under Article 87(1) of the EC Treaty[43]. In order to qualify for this exemption, R&D aid must either promote the execution of an important project of common European interest or facilitate the development of certain economic activities (as long as it does not adversely affect trading conditions to an extent contrary to the common interest). The Framework forms an essential part of the system of control of state aids with horizontal objectives[44]. Because the underlying objectives are not explicitly selective, these aids are regarded with more favour than aids granted to specific sectors of the economy or on an ad hoc basis[45]. It is considered that in the case of horizontal aids the beneficial effects in addressing market failures are more likely to outweigh the negative impact on competition.

59. The economic justification for granting state aid to research activities and which has led to the establishment of the Framework is essentially grounded on market failures arguments, namely the wider social benefits from R&D (contributing to growth, competitiveness and employment) and the often considerable financial requirements and risks of R&D activities. It is also considered that, given the distance from the market-place of R&D projects, the distortive effects of state aid on market competition and trade are relatively limited.

60. It is worth noting that Treaty rules, including competition rules, apply only to gainful activities, whether undertaken by private or public organisations. Therefore public support to non-profit making institutions such as universities or government laboratories is not considered state aid unless it confers an advantage to commercial firms. Also, to be caught by the words of Article 87 the measure must be selective, i.e. it must "favour certain undertakings or the production of certain goods", and thus affect the balance between the recipient firm and its competitors. This selective character distinguishes state aid measures from general economic support measures, which apply across the board to all firms in all sectors of economic activity in a Member State. As long as they do not favour a particular area of activity, such measures do not constitute state aid for purposes of Article 87. Finally, for Article 87 to apply, state aids must distort competition and affect trade between Member States[46].

Differentiating the intensity of state aid

61. The Framework differentiates the levels of aid intensity[47] according to the kind of R&D to be supported. Three stages of R&D are identified (fundamental research, industrial

---

[43] Whereby "any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the common market."

[44] This also includes aid for environmental protection, the promotion of SMEs and employment and the support to deprived urban areas. While being highly selective and distortive, state aids to rescue and restructuring are also formally included among horizontal aids.

[45] In reality However, even horizontal aid will be felt differently across sectors and companies.

[46] The principle *de minimis non curat lex* also applies to State aid.

[47] Amount of the aid as a percentage of the cost of R&D

research and pre-competitive development activity) benefiting from decreasing levels of aid intensity (respectively 100%, 50% and 25%). In differentiating the permitted aid intensity, the Framework acknowledges that state aids are more likely to distort competition and trade between Member States the closer the research is to its commercial application. A further implicit consideration is that more “downstream” types of R&D suffer from relatively less market failures. Along the same lines, the Framework does not consider innovation activities as a separate category of R&D[48].

62. The Framework provides that these ceilings on aid intensity may be exceeded by specific percentages in case the R&D project to be supported is undertaken by a SME or is carried out in a disadvantaged region. Recognising the social benefits of R&D externalities, the Framework allows for higher aid intensities when the project's results are widely disseminated and published and patent licences are granted. The Framework also encourages co-operation in the conduct of R&D and indeed projects involving cross-border co-operation between companies from at least two Member States or entailing the co-operation between firms and public research bodies benefit from a 10% bonus. However, the combination of all these increases may not exceed a maximum gross intensity of 75 % for industrial research and 50 % for pre-competitive development activities.[49]

63. The separation between the different stages of R&D, and particularly between industrial research and pre-competitive development has been sometimes criticised as static and not reflecting business reality. While there is general agreement on the specific nature of basic research –in which business gets rarely involved and which remains the main domain of universities and government laboratories- some have proposed merging the two other categories. This would simplify the calculation of aid intensity but, if resulting in higher overall levels of aid intensity, would increase the risks of distorting competition and trade between Member States. Also, accepting such a proposal would weaken the link between the extent of market failure identified and the related “corrective” measure. As an alternative, it has been proposed to strengthen the link between the aid intensity allowed and the targeted market failures, based on the assessment of the extent to which issues of appropriability and risk discourage private investment in a specific project.

The concern about additionality

64. Acknowledging the risks of crowding out of private investment, the Framework explicitly indicates that state aid to R&D should encourage firms to undertake R&D in addition to their normal day-to-day operations and promote R&D among firms not currently carrying it out. For this purpose, a condition on the additionality of public funds over private R&D has been included in the Framework, whereby “the Commission will consider aid less favourably than it usually does” where this incentive effect is not evident. In order to verify for possible crowding out effects, the Commission relies on quantifiable factors of the intensity of research efforts[50], market failures and additional costs connected with cross-border co-operation. The Framework provides that if the aid recipient is a SME, the incentive effect should be assumed.

[48] Aid for innovative activities that does not correspond to the three categories of R&D identified are not eligible for support unless they conform with the Commission policy on regional investment aid or aid to SMEs.

[49] These correspond to the maximum intensities authorised by the Agreement on Subsidies and Countervailing Measures for non-actionable subsidies. These maximum intensities can also be attained if similar projects by competitors located outside the EU have received or are going to receive, aid of an equivalent intensity.

[50] e.g. levels of R& D expenditure, number of people assigned to R&D, R&D spending as a proportion of total turnover

65. Despite its importance, this condition has had a mixed impact on the assessment of state aid cases. It is indeed rather difficult to overcome to problem of asymmetry of information and determine whether the R&D project proposed for funding is truly additional. It has also been noted that this principle may discriminate against large companies (SMEs benefit from a favourable presumption) by urging them to invest in R&D activities unrelated to their core business (since otherwise it might be considered that they would have undertaken the investment anyhow).

References

J. Adams "Endogenous R&D spillovers and industrial research productivity", NBER WP 7484 (January 2000)

J. Adams, E. Chiang and J. Jensen "The influence of Federal laboratory R&D on industrial research", NBER WP 7612 (March 2000)

J. Adams, E. Chiang and K. Starkey "Industry-university co-operative research centers", NBER WP 7843 (August 2000)

Bengt-Åke Lundvall, Susana Borrás "The globalising learning economy: implications for innovation policy", Report based on contributions from seven projects under the TSER programme DG XII, Commission of the European Communities (December 1997)

N. Bloom, R. Griffith, A. Klemm "Issues in the design and implementation of a R&D tax credit for UK firms", Briefing Note N°15, Institute for fiscal studies (January 2001)

L. Branstetter and M. Sakakibara "When do research consortia work well and why? Evidence from Japanese panel data", NBER WP 7972 (October 2000)

D. Czarnitzki and A. Fier "Do R&D subsidies matter? Evidence for the German service sector", Centre for European Economic Research, Mannheim (March 2001)

M. Dagenais, P. Mohnen, P. Therrien "Do Canadian firms respond to fiscal incentives to Research and development?", CIRANO, Scientific series (1998)

P. David and B. Hall "Heart of darkness: modeling public-private interactions inside the R&D black box", NBER WP 7538 (February 2000)

P. David, B. Hall and A. Toole "Is public R&D a complement or substitute for private R&D? A review of econometric evidence", Research Policy (September 1999)

E. Duguet "Les aides publiques augmentent-elles les dépenses privées de recherche et développement?", Working Paper (December 2000)

ETAN "The ETAN Group report on the promotion of employment in research and innovation through indirect measures", report to the European Commission (1999)

European Commission "Corporation tax and innovation: issues at stake and review of European Union experiences in the nineties", forthcoming study for DG Enterprise, European Commission (January 2002)

C. Freeman and L. Soefe "The economics of industrial innovation", Pinter (1997)

P. Geroski "Markets for technology: knowledge, innovation and appropriability", in Stoneman "Handbook of the economics of innovation and technological change", Blackwell (1995)

P. Geroski, Samiei and Van Reenen "Innovations, patents and cash flow", CEPR WP (1996)

Gomez-Acebo & Pombo Abogados "Impact of EU competition legislation on innovation", Study undertaken under a contract with DG Enterprise, Commission of the European Communities (November 2000)

A. Goodacre and I. Tonks "Finance and technological change", in Stoneman "Handbook of the economics of innovation and technological change", Blackwell (1995)

R. Griffith "How important is business R&D for economic growth and should the government subsidise it?", Briefing Note N°12, The institute for fiscal studies (October 2000)

Z. Griliches "The search for R&D spillovers", The Scandinavian Journal of Economics (1992)

B. Hall "R&D tax policy during the 1980s: success or failure?", Economic WP, University of California at Berkeley (1993)

B. Hall and J. Van Reenen "How effective are fiscal incentives for R&D A review of the evidence", NBER WP 7098 (April 2000)

C. Jones and J. Williams "Too much of a good thing? The economics of investment in R&D", NBER WP 7283 (August 1999)

T. Klette, J. Moen and Z. Griliches "Do subsidies to commercial R&D reduce market failures ? Microeconomic evaluation studies" NBER WP6947 (February 1999)

T. Klette and J. Moen "R&D investment responses to R&D subsidies: a theoretical analysis and a microeconometric study", Proceedings of the conference on The Economics of Science and Technology: Micro Foundations and Policy, Urbino (5-6 June 1998)

S. Lach "Do subsidies stimulate or displace private R&D? Evidence from Israel", NBER WP 7943 (October 2000)

S. Martin and J. Scott "The nature of innovation market failure and the design of public support for private innovation", Journal of economic literature (1999)

S. Metcalfe "The economic foundations of technology policy: equilibrium and evolutionary perspectives", in Stoneman "Handbook of the economics of innovation and technological change", Blackwell (1995)

OECD "Public funding of R&D: emerging policy issues" (2001)

OECD "New policies for a new economy: emerging issues in public funding for R&D" (2000)

OECD "Innovation and economic performance" (2000)

OECD and European Commission "The measurement of scientific and technological activities: proposed guidelines for collecting and interpreting technological innovation data – Oslo Manual"

OECD “Main definitions and conventions for the measurement of research and experimental development: a summary of the Frascati Manual 1993 (1994)

S. Stern, M. Porter and J. Furman “The determinant of national innovative capacity”, NBER WP 7876 (September 2000)

P. Stoneman “The economic analysis of technology policy”, Clarendon Press (1987)

“Handbook of the economics of innovation and technological change”, edited by P. Stoneman, Blackwell (1995)