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Innovation Policy: Europe or the Member States?

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Abstract in English

Innovation seldom has purely domestic causes and consequences, but how can a European innovation policy complement or substitute national policies? Taking the subsidiarity principle as a starting point, this report discusses the economic rationale of a European innovation policy. Explorative empirical analysis suggests that public R&D and public funding of private R&D are subject to economies of scale and external effects. This is an argument in favour of a European innovation policy but amongst other things, the heterogeneity in social economic objectives on public R&D spending between Member States pleas for national government involvement. In addition, there are scale economies in the protection of intellectual property and in the development of standards. We conclude that a European innovation policy could have, or already has, substantial benefits over purely national policy in these areas. With respect to innovation policies targeted at SMEs, we do not find economies of scale or external effects. It seems to be efficient that these policies are mainly conducted at the national level.

Key words: innovation policy, subsidiarity, European Union
JEL code: O38, H77, H87, F15

Abstract in Dutch

Innovatie heeft zelden uitsluitend binnenlandse oorzaken en gevolgen, maar hoe kan een Europees innovatiebeleid nationaal innovatiebeleid aanvullen of vervangen? Dit rapport evalueert de economische argumenten voor een Europees innovatiebeleid en neemt daarbij het subsidiariteitprincipe als uitgangspunt. Verkennend empirisch onderzoek geeft aan dat publieke onderzoek en ontwikkeling (O&O) en publiek gefinancierde private O&O onderhevig zijn aan schaalvoordelen en externe effecten. Dit kan een reden zijn voor een Europees innovatiebeleid, maar ondermeer de verscheidenheid in sociaal-economische doelstellingen van publieke onderzoeksuitgaven tussen de lidstaten pleit voor een grote betrokkenheid van de nationale lidstaten. Daarnaast komen schaalvoordelen voor bij de bescherming van intellectueel eigendom en bij de ontwikkeling van standaarden. We concluderen dat op deze gebieden een Europees innovatiebeleid substantiële voordelen kan hebben, of al heeft, ten opzichte van het voeren van uitsluitend nationaal beleid. Voor innovatiebeleid gericht op het midden- en kleinbedrijf vinden we geen schaalvoordelen of externe effecten. Het lijkt efficiënt dat dit beleid vooral op nationaal niveau wordt uitgevoerd.

Steekwoorden: innovatiebeleid, subsidiariteit, Europa,

Een uitgebreide Nederlandse samenvatting is beschikbaar via www.cpb.nl.

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Preface

Innovation policy is on the rise in Europe. Most European countries try to stimulate innovation as a means to increase productivity (growth). In 2000 the Member States of the European Union agreed to increase R&D spending towards 3% of GDP. Now and then initiatives are launched to increase expenditures on innovation and research in the EU budget. This raises the question whether innovation policies should be conducted at the level of national governments or at the European level. This document addresses this question from the subsidiarity principle. It is the second part of a CPB study on knowledge in Europe. This study is commissioned by the Dutch Ministry of Economic affairs. The first part of the study on higher education has been conducted by Laura Thissen and Sjef Ederveen and has been published as CPB Discussion Paper 68 in July 2006.

Albert van der Horst, Arjan Lejour, and Bas Straathof digged into the question of the appropriate government level for innovation policy. They benefited from constructive comments by their CPB colleagues Maarten Cornet, George Gelauff and Björn Vroomen, as well as by their former colleague Sjef Ederveen. They also want to thank the sounding board for their contribution in guiding this project, in particular Sander Baljé, Odilia Knap, Stephan Raes and Gideon van Staaij (all from Ministry of Economic Affairs).

Coen Teulings
Director

Summary

Nowadays, Europe focuses on innovation as a solution to its poor productivity growth. Europe's growth figures look pale in comparison with those of the US and many Asian countries, most notably China and India. Although growth in the latter countries is due to catching up, many people are worried about Europe's role in the world economy. Productivity increases would blush Europe's economy. The EU Member States agreed to increase R&D spending and many policy initiatives emerge to stimulate innovation at the European, national and regional level. At this moment, national governments spend about 65 billion euros on public research per year and the European Commission about 8 billion euros (the yearly budget of the Seventh Framework Programme and the Competitiveness and Innovation Framework Programme). Given the total amount of 73 billion euros, should the division between national and European spending be altered? This document discusses the appropriate decision level of innovation policy. Is there a role for European coordination and a European budget or do national governments have the primacy for innovation policy (as it seems now)? Is a Community Patent desirable and what is the role for Europe in stimulating innovation by Small- and Medium-sized Enterprises (SMEs)? These questions are analysed from the perspective of the subsidiarity principle. Are there economies of scale or external effects that can be internalised through coordination of national innovation policies in Europe? Or is the heterogeneity in policy objectives, structure of the economy or preferences in Europe too large to conduct innovation policies efficiently from Brussels?

Innovation policy covers many areas including public research and development (R&D), public funding of private R&D, Small- and Medium-sized Enterprises (SMEs), entrepreneurship and venture capital, and policies dealing with intellectual property rights (IPRs) and standards. For each of these areas, we assess the appropriate policy level: coordination at the EU-level or decision power by national governments. Economies of scale and external effects would support coordination of innovation policy at the EU level, whereas national policies are to be preferred in cases with strong heterogeneity in objectives, preferences or economic structure. In analysing economies of scale and external effects we use amongst others data on R&D spending. These data are input indicators and not output indicators on innovation. In comparing Member States, we implicitly assume that the efficiency of national innovation policies does not vary.

Public funding of R&D

We have compared the relative size of public R&D expenditure to the size of the economy for about 25 countries. Public R&D consists of government R&D, e.g. R&D by public enterprises, and research funds for universities and other institutes for higher education. It ranges from 0.2% in small countries, like Luxembourg, to 1% in Finland and Sweden. Both scale economies and

external effects are present in public R&D. Larger economies such as Japan, United States and Germany spend relatively more on public R&D than smaller economies and (smaller) countries which are more open to trade spend relatively less on public R&D. This favours coordination of public research and development at the European level. For research projects characterised by large indivisibilities, European coordination is certainly desirable. However, the arguments for European coordination have to be weighted against the heterogeneity in policy objectives. The data show a large variety in socio-economic objectives in innovation. We interpret this as an indication for heterogeneity between Member States. National policies are probably better suited to cope with this heterogeneity which lend support to the current role of national governments in public R&D. Overall, we conclude that there are some reasons for coordinating public R&D by the European Commission, in particular for large projects characterised by indivisibility, and that other objectives could be better served by national authorities.

Governments are not only active in public R&D but also in supporting private R&D with public funds. The size of these funds is on average much smaller than for public R&D. There is some evidence of scale economies and external effects in the public funding of private R&D. The data show that larger economies provide relatively more support for private R&D. These economies of scale could be due to fixed costs in providing public support for private R&D, such as monitoring or establishing an office or government agency for that purpose. Cross border externalities are significant in private R&D, which implies that part of the benefits of public funding of private R&D likely leaks abroad. However, the likely implication that governments of open economies spend less on public funding is not supported by the available data.

We do not have specific data on the objectives of Member States regarding the public finance of private R&D, but the data on the objectives of publicly funded R&D as well as the literature suggest that the heterogeneity is large. Weighting these arguments, we arrive at a similar conclusion as for public R&D. The presence of scale economies and external effects support EU involvement in areas where national policy objectives match. Otherwise, national governments can better take account of the particular characteristics of the country regarding the sector structure, the innovation system, and preferences.

Europe’s role in funding public R&D and private R&D is gaining momentum. Currently, the main instrument of the European Commission for funding R&D is the Seventh framework Programme (FP7). For the period 2007-2013, the budget is 53 billion euros. Under FP7, subsidies are granted for public and private research in Europe in order to “pool and leverage resources, foster human capital and excellence, and to better integrate R&D policies”. Most of these arguments refer to possible economies of scale in public research and the public funding of private research. Because the evidence suggests the presence of economies of scale and external effects, most of the programmes within FP7 cannot be rejected from the subsidiarity perspective.

Small- and Medium-sized Enterprises

Governments often formulate innovation policies targeted at SMEs. Compared to large companies SMEs often have less access to capital markets, and less access to new technologies and new ideas. Government support could overcome this lack of access. The lack of access does not apply to all SMEs in the same degree, but depends on the characteristics of the enterprise. According to the definition of the EU, the size of SMEs ranges from self-employed to large exporting firms with up to 250 employees. Many SMEs often operate at the regional or national level. Their channels for knowledge and innovation are often regional or even local. Others operate at an international level, but this is a minority of the SMEs. This suggests that there will be no important economies of scale in innovation policies for SMEs in general. Scarce data material also confirms this view: there is no significant relation between the proportion of SMEs that receives public funding for innovation and the size of the economy. Neither does the proportion of SMEs reporting public funding depend negatively on their activities abroad, such that SME policy is unlikely to suffer from external effects. From the subsidiarity perspective there are no compelling reasons for conducting SME policies at the European level. The national level seems to be the most appropriate level for these policies because since there are no firm indications for economies of scale or the existence of external effects.

The Competitiveness and Innovation framework Programme (CIP) of the European Commission, with a relatively small budget of 4 billion euros in 2007-2013, is targeted to SMEs. Part of the program intends to ease the supply of seed and early stage capital for innovative start-ups. European involvement in innovation policy for SMEs is justified from the subsidiarity perspective insofar CIP meets the goals of reducing regulations for innovative SMEs and of promoting policy learning between Member States. A small part of the programme deals with sustainable development and energy in Europe. The externalities in this specific area justify Europe’s involvement.

Patents and standards

Patents are important for fostering innovation because they provide an incentive for innovation and because they promote the diffusion of knowledge. The economies of scale for a single patent system in the European Union seem obvious. Currently, patents can be applied for at the European Patent Office (EPO), but once a patent is accepted by EPO, it is granted by individual countries under national legislation, which includes translation requirements. Litigation is also a national affair. A single patent for the EU – a Community Patent – within the jurisdiction of a European Patent Court could dramatically reduce the costs of acquiring a patent valid in all countries of the EU. However, attempts to establish a Community Patent have failed so far – officially on language related issues, but more likely out of protectionism and the vested interest of the patent industry. From the perspective of subsidiarity the gains from a Community Patent are likely large.

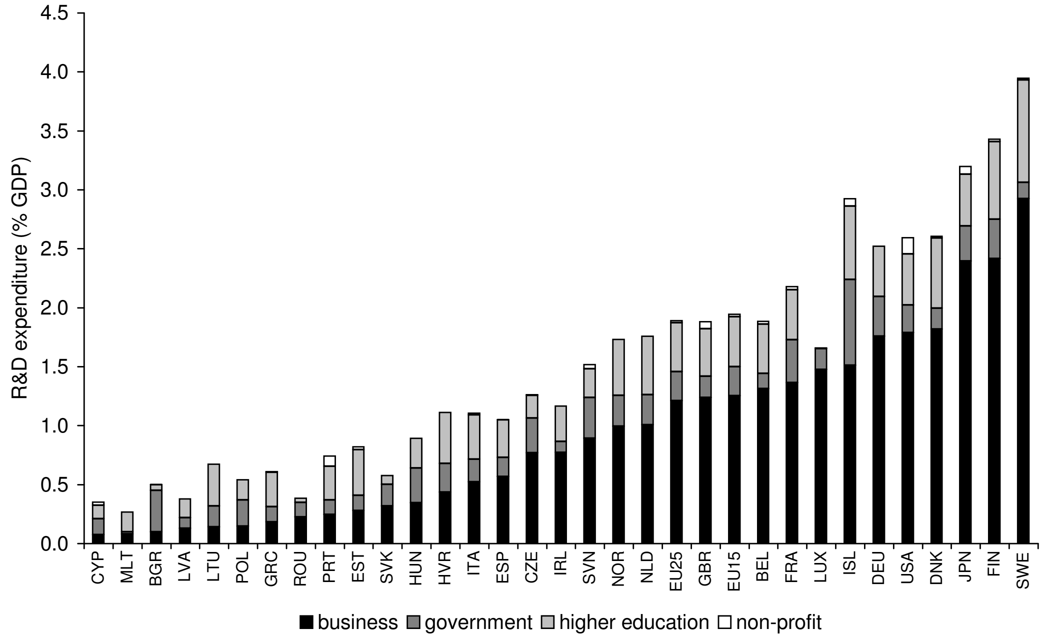
There is a tradition of European coordination of standards. Coordination reaps the benefits of economies of scale. It is cheaper setting standards Europe-wide than by each country individually. Moreover, European standards have the advantage that these are uniform over Europe, which benefits producers and consumers. Generally, standards are being developed by standard setting organisations (SSOs), which are semi-private institutions. These organisations generally are capable of preventing market failure in the form of lock-in into ex-ante inferior standards and a lack of standards. SSOs operate independently of the European Commission and national governments, except in areas related to safety, health and environment. In these areas, the EC commissions the development of standards to one of the three European SSOs. As such, standardisation related to EC regulation is, and should be, centralised at the European level.

1 Introduction

Innovation policy is on the rise in Europe. The European Commission has doubled its budget for innovation policy for the coming years (2007-2013). The Directorate-General (DG) Enterprise and Industry has launched the Competitiveness and Innovation framework Programme (CIP) with a total budget of € 3.6 billion for the period 2007-2013. In addition, DG Research is working on the Seventh Research Framework Programme (FP7), with a proposed budget of € 53.2 billion for the same period. Still, the budget is only a small share, about a tenth, of the public expenditures on R&D by the Member States, which has fluctuated about 0.65 per cent GDP since the early 1980's.[1]

In March 2000 the Lisbon European Council defined the goal for the EU to become the 'most competitive and dynamic knowledge-based economy in the world by 2010'. The European Union has concluded that investment in European research and development (R&D) must be increased to 3 per cent of GDP in 2010. This target is ambitious given the current R&D share of about 2 per cent. Only Finland and Sweden have R&D shares exceeding the three per cent target.

Figure 1.1 R&D expenditure by private sector and government (2003)



Source: Eurostat; a list of country codes is provided in Annex A

[1] Data for EU15. Source: OECD (2005), Main Science and Technology Indicators 2005-2.

The ‘Lisbon agenda’ explicitly acknowledges the role of the business sector in research and development: at least two thirds of the total R&D expenditures (equal to 2 per cent GDP) should come from the private sector. Again, the ambition by far exceeds the current expenditures, which varies between 0.2 per cent of GDP in countries like Poland and Greece and 3.0 per cent in Sweden, see Figure 1.1. Moreover, private R&D expenditures did not show a clear upward trend in the recent decades – it fluctuated between 1.1 and 1.25% of European GDP.

This raises the question how the private sector in the Member States can be triggered to intensify their investments in R&D, or more generally, to become more innovative. One part of this question, which has been extensively investigated by Cornet et al. (2006a), is which policies are likely to be successful in stimulating private R&D or raising productivity. They showed for the Dutch economy that, among other policies, expansion of the provisions for starting innovating companies and expansion of public support for funds that supply small amounts of venture capital loans are likely to be successful.[2]

The second part of the question how innovation can be stimulated is whether or not innovation policy should be coordinated at the European level, or should be left to the Member States. This is the central question in this paper. The prime reasons for coordinating innovation policy is to benefit from economies of scale caused by fixed cost and to overcome the negative effects of cross-border externalities, such as knowledge spillovers (Ederveen et al. (2006)). Cross-border externalities reduce the incentive for policy and thus lead to so-called policy externalities. European coordination can lead to a more efficient innovation policy as it can internalise these policy externalities. The key disadvantage of coordination is, however, that a European policy is less able to deal with location specific factors. The current document is an attempt to weigh the pros and cons of European coordination in innovation policy. In other words: is European innovation policy consistent with the subsidiarity principle, which states that a policy should only be adopted by the EC when Member States themselves cannot achieve equivalent or superior results?

Little research has been done on desirability of European coordination of innovation policy so far. Hence, we perform an *explorative* empirical analysis of the economies of scale, cross-border externalities and heterogeneity in each policy instrument. Given the limited availability of empirical evidence, our conclusions will be quite tentatively. In analysing economies of scale of external effects we use amongst others data on R&D spending. These data are input indicators and not output indicators on innovation. In comparing Member States on economies of scale we implicitly assume that the efficiency of national innovation policies does not vary. Relative large R&D spending on large countries we interpret as a signal for economies of scale, but in theory these countries could need more inputs to cope with inefficiencies in innovation.

[2] Other potentially successful policies are easier access to the Netherlands for well educated foreigners and making government funding of university research more conditional on research performance.

Innovation is a very broad concept. The European Commission (2005a) stresses the business component by defining innovation as a business process connected with exploiting market opportunities for new products, services and business processes. The Dutch government stresses the human factor by characterising innovation as improving the development and use of the possibilities of people.[3] As innovation is very broadly defined, this is also the case for innovation policy. We have to limit ourselves in the range of policies we deal with. First, we only deal with policies directly supporting innovation and leave aside policies which support innovation indirectly. Examples of the latter are trade liberalisation (see Eaton et al. (1998)), competition policy (see Encaoua and Hollander (2002) and Griffith et al. (2006)) and policies improving mobility of institutions, people and resources (see Aho et al. (2006)).[4] Secondly, education plays a key role in improving the innovative capacity of an economy. The role of the European Union in higher education has been investigated by Thissen and Ederveen (2006) in a companying paper. They find little support for European coordination of higher education.

We selected four types of innovation policies which, according to our observation, are prominent in the European Union. First, we investigate the most direct type of innovation policy namely public investment in research and development (R&D). Next, we turn to the public financing of private R&D. Thirdly, the focus is shifted from the financing of innovation towards the conditions in which firms are able to develop and sell their innovations and innovative products. In particular, we pay attention to the small and medium sized enterprises (SMEs) for which innovation depends crucially on entrepreneurship and the acquirement of venture capital. In addition, we discuss intellectual property rights and standards. Among the types of innovation policies (see OECD (2006)) which are left out are eduation policies (already dealt with in Thissen and Ederveen (2006)) and industry-science linkages (upon we briefly comment in Chapter 4).

The report is structured as follows. Chapter 2 discusses the market imperfections in innovation. Chapter 3 outlines how the principles of subsidiarity as formulated by Ederveen et al. (2006) apply to innovation policy. These principles are used in the succeeding chapters to evaluate the selected types of innovation policies. Chapter 4 focuses on public investment in R&D, Chapter 5 on public funding of private R&D, Chapter 6 on SMEs and venture capital and Chapter 7 on intellectual property rights and standards. In Chapter 8 we apply the insights of the previous chapters to the EU programs on innovation, namely the Seventh Framework Programme (FP7) and the Competitiveness and Innovation framework Programme (CIP). In each section we draw conclusions on the benefits of European coordination of innovation policy. These conclusions are reiterated in the Summary.

[3] www.innovatieplatform.nl

[4] See also Sociaal-Economische Raad (2004).

2 Market failures in the European economy

Innovation policy generally aims at overcoming market failures that hamper innovation.[5] In countries with an isolated, autarkic economy such market failures can be dealt with by domestic policy alone. Autarky, however, is a thing of the distant past for the countries of the European Union. A process of economic integration has been progressing for centuries in Europe. Economic integration not only has brought wealth, but also has made the economic policies of Member States increasingly interdependent. In this section, we first introduce various types of market failure that provide the theoretical basis for innovation policy. After this overview, we summarise the empirical evidence on the impact of economic integration on research undertaken in the private sector.

2.1 Market imperfections

Innovation policy comes in a variety of forms. This variety is a reflection of the wide range of market failures it wishes to address. The most important types of market failure hampering innovation are due to:

1. Knowledge diffusion
2. Buyer surpluses
3. Duplication of research
4. Inefficient standardisation
5. Asymmetric information
6. Economies of scale

2.1.1 Knowledge diffusion

Diffusion of knowledge beyond a firm's border is not completely avoidable. Leakage of knowledge can occur because a production method can be inferred from the products sold by the firm or because employees switch jobs. As an externality knowledge diffusion can take three forms, each with a different effect on the innovator:

- Imitation in markets not served by the innovator,
- (Threat of) imitation by competitors,
- Applications of innovations unintended by the innovator.

The first kind of diffusion externality can arise when an inventor is unaware of the commercial possibilities of the invention, or when the inventor does not have access to all potential markets

[5] Market failure can also lead to too much innovation. Jones and Williams (2000), however, argue that this unlikely to occur.

because of protectionism by governments, cartels or other barriers. If the original inventor is unable to access a market this does not automatically imply that the invention will never reach this market as other (local) firms might be able to sell imitations. Although imitation raises welfare when the original inventor cannot access a market, this is still not an optimal outcome because the incentive for innovation does not reflect potential demand.

Market-access can be promoted through indirect innovation policies such as trade-liberalisation and competition policy (which are outside the scope of this report). Alternatively, the cost of trade-barriers can be reduced by means of subsidies on the export or import of innovative products, but this is clearly a second-best policy.

A second form of externality induced by knowledge diffusion is caused by the often limited capability of firms to protect their intellectual property. When an innovation is imitated by competitors the revenues of the innovating firm diminish substantially.[6] For this reason, the threat of imitation alone can be enough to discourage innovation. Imitation can be reduced by protection of intellectual property rights (IPRs) through copyright laws and patent systems. Branstetter et al. (2006) report that U.S. multinational firms have increased R&D expenditure by affiliates in countries that have adopted stronger IPR protection.

The third diffusion externality is that an innovation can sometimes be applied in ways other than those originally envisioned by the innovator: one innovation provides the inspiration for another innovation. In the literature, this kind of externality is usually referred to as "knowledge spillovers" or the "standing on the shoulders of giants"-effect (after Newton). The invention of the transistor is a good example of this phenomenon. The developers of early transistors in the first half of the 20th century could not have imagined the role played by computers today. In particular, many innovations and scientific breakthroughs would have been impossible without transistors. Open source software provides a more recent example of the importance of this externality (Lerner and Tirole (2005) and Maurer and Scotchmer (2006)).

Because of the standing-on-shoulders effect the (potential) social value of an innovation is not limited to the sum of the deadweight loss and consumer and producer surpluses, but also includes a share of the value of subsequent innovations. Innovation policy aiming to internalise this externality faces the difficult task to facilitate the diffusion of knowledge without removing the incentive to innovate. This trade-off is especially relevant for the design of patent systems, which have the dual task of protecting IPRs and promoting diffusion of knowledge. A shorter duration of patents, for example, reduces the incentives to invent, but encourages the diffusion of knowledge, which provides opportunities for other inventions. In addition, subsidies can be given to research that promises to deliver innovations with great social value.

[6] If a competitor introduces a new product that has a higher quality (or lower production cost) than the original product, the original producer can even loose all of its revenues. In the economic literature this is known as 'business-stealing'. Aghion and Howitt (1992) have shown that business stealing can lead to overinvestment in R&D.

2.1.2 Buyer surpluses

Not all the benefits of an innovation accrue to the innovator: the customers of the innovator receive more than what they pay for. As firms usually cannot discriminate perfectly between buyers, they have to set a single price for all customers, or, at best, they can set a single price for various types of customers. As a consequence some customers pay less than what they are willing to – which leads to a ‘consumer surplus’ or ‘rent-spillover’. Moreover, some potential customers do not buy the product even though they are willing to pay more than marginal cost, which results in a ‘deadweight loss’. The inability to discriminate perfectly between customers makes that innovators are rewarded only a part of the (potential) social value generated by an innovation and therefore they will innovate less than they should from a social planner’s perspective. Econometric studies have shown that the surplus generated by new products can be substantial. In a remarkable study, Hausman (1997) finds that the introduction of a new kind of cereal, Apple-Cinnamon Cheerio’s, has led to gain in consumer surplus of $66.8 million per year.[7]

Example of a buyer surplus: developing a new drug

Consider the development of a new drug by a pharmaceutical company. If the company is not capable of discriminating between customers, then the company has to set a single price for all customers. Some customers will be able to pay this price, while the price will be too high for others. If the company would be able to sell the drug against personalised prices, every patient willing to pay at least the marginal cost will buy the drug. Not only would this raise the number of customers that are treated, but this would also increase the revenue from customers willing to pay at least the non-differentiated monopoly price.

Suppose the expected non-differentiated monopoly profits from producing a new drug are not sufficient to cover the cost of development and testing, then a government might induce the firm to develop the new drug anyway by giving a subsidy on R&D. Such a policy can improve welfare even though the drug will only be available for customers willing to pay the monopoly price. Alternatively, a government might subsidise the sales of the drug itself, which will allow more customers to use the drug *and* simultaneously increase the incentive for developing the drug.

Typically, a drug is sold in many countries in the world. This raises the question of which country will subsidise the drugs for which the incentives for development and testing are insufficient. If the required subsidy is relatively small then a country with a high GDP might find it worthwhile to finance the subsidy – even when this gives other countries a free ride. When a larger subsidy is required, no single country might be willing to pay for the subsidy alone. In this situation cooperation between countries is necessary for the drug to be made available to customers.

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[7] Inspired by the works of Hicks (1940), Hausman (1981, 1997) has developed a methodology for estimating the welfare gains that arise from the introduction of a new good. Later contributions in this direction include the work by Petrin (2002), Goolsbee and Petrin (2001), and Nevo (2003). Authors that have studied the surplus of new goods using alternative approaches are Trajtenberg (1989), Brynjolfsson (1997), and Berry et al. (2004).

2.1.3 Duplication of research

Firms developing a new product usually are not aware of each other's activities. As a consequence, two or more firms might end up doing the same research, which is a waste of resources. In principle, this problem can be avoided if firms make public what kind of product they are developing. There are two reasons why they might not do so. First, by making public their research agenda they might reveal information that benefits competitors. Second, firms might not be inclined to adapt their research agenda even if they know another firm is doing the same research because there is a possibility that they can get a patent before the other firms (Reinganum (1982), Dasgupta (1988)).

In the first situation, a patent system can help to prevent the duplication of research as it allows firms to make their knowledge public without loosing the rents associated with invention. In the second case, strong protection of patents can actually increase duplication if the value of the exclusive right on an invention substantially exceeds the (expected) cost of developing the product.

2.1.4 Inefficient standardisation

Standardisation allows one type of product to be interoperable with other types of products. Users can benefit from interoperable products because of added functionality and lower cost, which raise demand and thereby attract new producers. For some products (e.g. cell-phones and computers) the value of the product also increases with the number of users. Without standardisation isolated groups of users and producers will coexist, such that the potential user-value of the product is not fully realised.

Failure to achieve efficient standardisation is a fourth type of market failure that offers a rationale for innovation policy. Markets may fail to provide efficient standards in three ways:

- Lock-in into inferior standards,
- Lack of standardisation or
- Excessive standardisation.

A classic example of lock-in is that of the QWERTY keyboard (David (1985)). Lock-in can happen when no single firm has an incentive to change the standard as the adjustment cost of its users is high. Farrell and Saloner (1985), (1986) and Katz and Shapiro (1985), (1986) show that lock-in into inferior standards can also arise in the context of oligopolistic competition. A lack of standardisation can occur when new technologies are cheap to introduce and consumers do not take into account network effects (Katz and Shapiro (1986)). Standardisation can be excessive if it leads to a loss in product variety. Katz and Shapiro (1985), (1986) demonstrate that this can occur when firms are sponsoring ("subsidising") their technologies.

If market failure prevents the efficient adoption of standards, a standard can be enforced by the government. However, experiences in telecommunications and information technology demonstrate that voluntary agreements can be very successful in setting standards. Two flavours of voluntary agreements have been studied in the literature. First, Lerner and Tirole (2005) and Maurer and Scotchmer (2006) review the literature on 'open source' arrangements that are popular in software development. Second, Farrell and Saloner (1988), Lerner and Tirole (2004) and Farhi et al. (2005) provide theoretical analyses of standard setting organisations (SSOs). Examples of influential SSOs are the International Organisation for Standardisation (ISO), International Telecommunications Union (ITU), the Institute of Electrical and Electronics Engineers (IEEE) and the Internet Engineering Task Force (IETF).

The empirical work on SSOs predominantly consists of case-studies.[8] A more systematic analysis can be found in Chiao et al. (2006). One of their findings is that mandatory royalty-free licensing is inversely related with disclosure requirements by SSOs. This indicates a trade-off between the openness of a standard and its quality, which depends on the willingness of participants to share their knowledge.

Governments generally have three instruments capable of promoting efficient standardisation. They can facilitate efficient standardisation by setting standards directly, by referring to voluntary standards developed by standards setting organisations (SSOs) and by ensuring fair competition between companies, such that the influence of dominant firms on the choice of a standard is kept in control. The latter strategy falls outside the scope of this report, but will be touched upon in Section 7.3. The first strategy is rarely adopted, instead governments generally leave the development of standards to SSOs. Reference to SSO standards in laws and regulation is common, but usually is confined to areas related to safety, health and environment.

SSOs are capable of reducing the first two forms of market failure. First, SSOs can reduce the chance of lock-in into an inferior standard as some form of consensus is usually sought on what the best standard would be before it is being set. These voluntary agreements have the important advantage over government intervention that the former provide an incentive for sharing knowledge, leading to superior standards. Second, SSOs provide a platform for interested parties to develop standards and they facilitate the dissemination of standards that have been agreed upon. In this way, SSOs can reduce market failure leading to a lack of standards.

2.1.5 Asymmetric information

The researchers working on a project know more about the chances of success than others. This asymmetry in information hinders the financing of R&D-projects. Hall (2002) discusses two reasons why R&D can be more costly to finance than other types of investment:

[8] For examples of case studies, see the references provided in Chiao et al. (2006, p. 6).

- Adverse selection between inventor and investor and
- Moral hazard from the inventor's side.

A potential investor in an R&D project has less information about the project than the researchers that are proposing the project. This introduces a problem of asymmetric information similar to the lemons problem of Akerlof (1970), which results in a 'funding gap' between the private provision of capital and what would be the socially optimal level (Myers and Majluf (1984) and Leland and Pyle (1977)). Revealing information about the project to potential investors does not solve this problem as this will lower the value of the project (Bhattacharya and Ritter (1983)). Evidence on a lemons problem for the financing of R&D has been presented by Alam and Walton (1995), Szewczyk et al. (1996) and Zantout (1997).

Lack of funding due to asymmetric information can be mitigated through interference by venture capitalists, who are specialised in monitoring start-up companies. Hall (2002), however, reports that venture capital is not sufficient to close the funding gap. Whether governments can close the gap through government incubators, seed funding or loan guarantees remains to be seen, as also the government is confronted with asymmetric information.

Moral hazard is another problem that hinders the financing of innovation. When the goals of investors and inventors are not identical, the former need to monitor the latter. However, Boocock and Woods (1997) show that the cost of monitoring reduces investors willingness to finance R&D-projects. Another instance of moral is studied by Hall (2002), who discusses the literature on conflicts of interest between shareholders and managers. Managers can be more risk averse than shareholders if the managers' outside options are less attractive than their current position. Risk aversion harms the interest of shareholders as it reduces investment in risky R&D-projects.

2.1.6 Economies of scale

Economies of scale can lead to market failure if they enable a company to capture such a market share that it leads to market power. The resulting reduction in competition not only increases the dead-weight loss on the product market, but also reduces some incentives for innovation. A monopolist is unlikely to develop product improvements as this would destroy the profits stemming from existing products.[9] When it comes to innovation, two classes of scale economies can be distinguished:

- Fixed cost
- Internalisation of externalities

[9] Aghion and Howitt (1992) labelled this phenomenon "creative destruction".

Expenditure on research almost always takes the form of fixed cost as research generally yields usable output only at the end of the R&D process. This convexity in the productivity of research implies that more complex innovations require higher upfront expenditure than less complicated innovations. For example, the development of a new drug tends to cost more than a new piece of software. Once developed, a new product can be sold in arbitrary numbers without raising development cost, which introduces an element of scale economies.

A second reason for economies of scale in research is that large companies internally can avoid or reduce market failure. To begin with, knowledge spillovers within the firm can be taken into account when funding research. A project with large spillovers to other projects within the firm can be worthwhile to fund even when such a project would be loss-making in the market. Another advantage of a large firm is that knowledge can diffuse relatively freely within the company without the risk of imitation. Better diffusion of knowledge also may improve the functioning of a firm's internal capital market. First, because duplication of research can be avoided. If the management of a company knows what the activities of each department are, it will be relatively straightforward to prevent duplication. Second, intra-firm knowledge diffusion helps to reduce asymmetry in information. Both adverse selection and moral hazard still may occur, but are likely to be less severe as employees generally have at least some incentives (e.g. a salary with profit-sharing) that are aligned with the company's interest. For these reasons more information is available on internal capital markets than on external capital markets. Hence, the risk premium on internal capital is below that of external capital.

Increasing returns to scale in research tend to reduce competition, but at the same time lead to lower cost of research. The former discourages innovation, while the latter facilitates it. Governments may counter anti-competitive behaviour by restricting the size of firms or even by splitting them up, but such a policy comes at the cost of a loss in the efficiency of research. Alternatively, governments can assign an independent (competition) authority with the task of monitoring and regulating industries in which competition is lacking. In the extreme case of a natural monopoly, governments may even decide to nationalise the monopolist.

2.2 Economic integration

The market imperfections described above can be an economic reason for the government to intervene. The importance of the various imperfections depends on country-specific conditions including the size of the market. Market size is affected by economic integration globally and more specifically in Europe. Before analysing the appropriate level of government intervention for innovation policies in Europe we sketch the consequences of market integration for innovation by firms. Economic integration affects research in the private sector through two channels:

- Firms can better exploit economies of scale, both in production and research
- Cross-border knowledge diffusion creates a larger knowledge base

This section evaluates a selection of the empirical evidence on the strength of both channels.

2.2.1 Scale economies for firms

Economic integration brings economies of scale for the private sector. These economies of scale occur both in production and in research. Considering the former, trade liberalisation makes it possible that a good can be produced in a single country and exported to other countries. In this way a firm can spread fixed production cost over a larger amount of goods, and, in addition, the firm can choose a country in which the conditions for production are most favourable. The resulting lower cost of production is likely to raise profitability. Higher profitability in turn provides an incentive to invent new products and improve existing ones.

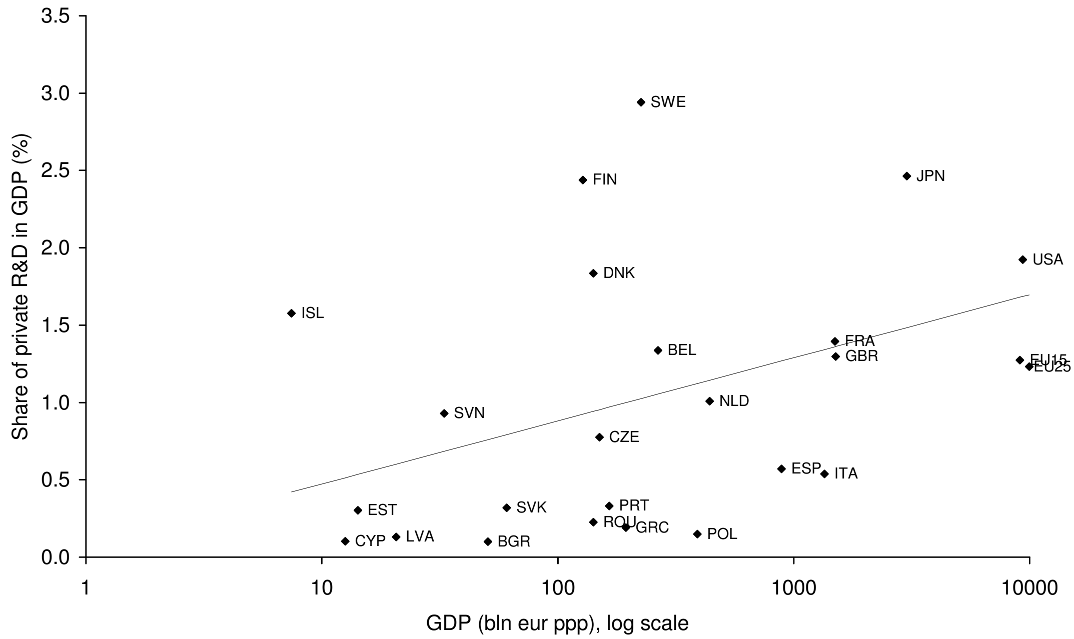
A similar argument can be made for scale economies in research itself. When a company is developing a product that can be sold everywhere in Europe, the profits of this company will be larger than if the same product could only be sold in a single country. Through its impact on scale economies in production and research, economic integration can greatly stimulate innovation.

Figure 2.1 displays the share of private R&D expenditure in GDP plotted against the size of the economy in terms of its gross domestic product (GDP). The figure suggests that the relative size of a country's private R&D is positively associated with its GDP. Two conclusions can be drawn from this graph. First, there is some evidence that the scale of the domestic market indeed matters for innovation. Second, other factors appear to be dominating the effect of the domestic market. The Nordic countries spend more on R&D than what is to be expected from their size, whereas Eastern-European countries spend less. A possible explanation for this pattern is that the Nordic countries perform research for the world market, while Eastern Europe lags behind for historical reasons.

The share of private R&D in GDP in the EU lies substantially below the regression line plotted in Figure 2.1. This suggests that less research is performed in the European Union than could have been expected from the EU's GDP. The outcome suggests that further economic integration in the European Union could induce an increase in private R&D of almost a half percent of GDP. Additional research is required to assess the reliability of this estimate.[10]

[10] The positive association between the share of R&D in GDP and GDP itself is unlikely to be caused exclusively by a causal link between R&D intensity and GDP per capita as the relation between the share of R&D in GDP and the size of the working population is also positive.

Figure 2.1 Economies of scale in private R&D (2003)



Source: Eurostat; a list of country codes is provided in Annex A
EU 15 and EU 25 have been omitted from regression.

2.2.2 A larger knowledge base

Besides lowering the average cost of firms in both production and research, economic integration also gives researchers access to a larger body of knowledge, thereby improving their productivity.

The empirical evidence on the diffusion of technology across borders is substantial and has (largely) been documented by Keller (2004). One strand of the literature is concerned with the relation between R&D and productivity and traces back to the Griliches (1979) and Jaffe (1986).[11] Coe and Helpman (1995) and Coe et al. (1997) have shown that not only domestic but also foreign R&D contributes to productivity. Jacobs et al. (2002) arrive at similar conclusions in a study of sectoral productivity growth in the Netherlands.

A complication that arises with this approach is that R&D can lead to higher productivity through innovation but also through imitation – the two faces of R&D emphasised by Cohen and Levinthal (1989). Levin et al. (1987) show that imitation is far from costless. They estimate that imitating a new invention can cost between 50 and 75 percent of what the original invention had cost. In two recent contributions Griffith et al. (2003) and Griffith et al. (2004) separate the effects of imitation and innovation and find that both channels are important for productivity growth, although imitation becomes less important if a country lies closer to the productivity frontier.

[11] Los and Verspagen (2006) provide a survey.

A more direct approach, which mainly captures the standing-on-shoulders type of knowledge diffusion is to measure diffusion using data on patent citations. In an early survey Griliches (1990) advocates the use of patent data because it does not require strong assumptions about the structure of spillovers that is required when trying to link R&D with productivity. Three years later Jaffe et al. (1993) presented evidence suggesting that knowledge diffusion is predominantly a local phenomenon. They found that the probability of one patent citing domestic patents is larger than foreign patents, that the probability of citing a patent from the same US-state is larger, and that the probability of citing a patent from the same region is larger again. This is a remarkable result as they controlled for the location of production. As production activities tend to be geographically clustered, it would not be a surprise to find back this clustering in patents that apply to the same product or production process. Jaffe et al. show that patent citations tend to be local even after the geographical clustering due to the clustering of production is taken into account. Later studies by, amongst others, Maurseth and Verspagen (2002) arrive at the same conclusions.[12] Using other approaches Keller (2002) and Thompson (2004) also have confirmed the findings of Jaffe at al.

A next question is whether knowledge diffusion is becoming less local over time. Some recent evidence suggests that this indeed the case. Using a new database on the diffusion of technologies, Comin et al. (2006) report that the rate of convergence between countries within a technology typically is around four percent per year and that the speed of convergence for technologies developed after 1925 is three times higher than for older technologies.

Summarising, the empirical literature on the diffusion of technology shows that knowledge does not stop at a country's border but also that knowledge does tend to be local in nature. Economic integration can lead to a larger knowledge base, but the extent of this effect is limited by the local nature of knowledge. Whether the diffusion of knowledge across borders is likely to discourage innovation policy at the national level is discussed in the succeeding chapters.

[12] Thompson and Fox Kean (2005a, 2005b) claim, in a reassessment of the article by Jaffe et al. (1993), that the local nature of patent citations is largely spurious and can be ascribed to inadequate control for the location of production. Henderson et al. (2005), however, pointed out that the alternative of Thompson and Fox-Kean is likely to have suffered from sample-selection bias

3 Subsidiarity of innovation policy

Should innovation policy be coordinated in the European Union or should it be left to the Member States? Ederveen et al. (2006) list several reasons for centralisation, but also for decentralisation, of policy (of any kind) at the European level. The main reasons for centralisation are economies of scale and policy externalities. Economies of scale in innovation policy can arise if designing and executing policy involve substantial fixed cost. Policy externalities arise if a country's innovation policy has unintended effects on other countries. Policy coordination can internalise these policy externalities. In fact, this internalisation is a kind of scale economy as innovation policy at a larger scale is less vulnerable to leakages across the border. Among the reasons for country-specific innovation policy are differences between Member States in preferences regarding innovation and innovation policy and heterogeneity in existing innovation policies.

In this report we make a distinction between three levels of policy integration: centralisation (policy executed by the EC), multilateral cooperation between national governments and independent national policies (no policy integration).[13] The advantages of centralisation are that fixed cost can be minimised and that policy externalities can be fully internalised. A disadvantage is that individual Member States cannot adjust innovation policy to local circumstances and preferences. Multilateral cooperation leaves more scope for local fine-tuning, but does not minimise fixed cost. The main benefit of cooperation over independent national policies is the internalisation of policy externalities. This chapter discusses scale economies and externalities in innovation policy and concludes with some remarks on heterogeneity of Member States.

3.1 Economies of scale due to fixed cost

In general, centralisation of policy might be more efficient than national policy because the fixed cost of public administration have to be incurred only once, instead of for every Member State. For example, if a policy needs to be implemented only at the European level, this will save the cost of implementation for each individual Member State. The same argument applies to the monitoring and enforcement of regulation. In particular, the selection and evaluation of research proposals require expertise that can be maintained more efficiently at a larger scale. The European Patent Office (EPO) is an example of how centralisation can reduce the cost of maintaining expertise in a wide range of fields (see Chapter 7).

[13] The distinction made here is a conceptual simplification that does not fully correspond to the actual organisation of the EU. One interpretation is that policy centralisation reflects the "Community Method" of the first pillar of the EU and that policy cooperation reflects the "Intergovernmental Method" adopted under the second and third pillar. Within the Community Method a second division can be made between a "regulation" and a "directive" . The latter only formulates goals and comes close to what is meant by cooperation.

Mulligan and Shleifer (2005) present evidence on economies of scale in public administration. They hypothesise that the cost of adopting a law are (approximately) independent of the size of a country. This makes the adoption of a law cheaper for large countries than for small ones. In accordance, large countries are expected to have a greater number of laws than small countries. Their empirical study shows that U.S. states with a larger population have more laws and adopt certain laws earlier than smaller states. In addition, Mulligan and Shleifer have conducted an analysis for a panel of 73 countries. Again they found evidence indicating that the size of a jurisdiction matters for the amount of regulation. For education and health, Dao (1995) shows that their provision is subject to scale economies in countries with large populations. Finally, Cohn et al. (1989) present some evidence on economies of scale in the public sector for research and graduate teaching based on U.S. data for 1981-82.

3.2 Policy externalities

The presence of policy externalities provides a second rationale for European coordination of innovation policy. Policy externalities arise when a national policy of a Member State has unintended consequences for another Member State Ederveen et al. (2006). A national R&D subsidy, for example, can benefit research beyond the borders of the domestic economy. If a government is not concerned with the favourable effects of its subsidy on other countries, the amount of subsidy is too small from a European perspective. A national policy might also have a negative effect on other countries. For example, a country might fail to protect the intellectual property of foreign firms, thereby facilitating imitation by domestic firms.

Both positive and negative policy externalities give rise to a prisoner's dilemma,[14] if all countries involved benefit from cooperation. Both centralisation and cooperation can be used to solve such a dilemma. The credibility of agreements can be ensured by legally binding treaties. In extreme cases, however, negative policy externalities do not lead to a prisoner's dilemma because not all countries would benefit from cooperation. A text-book example is a tax-heaven. Small countries like Monaco, Liechtenstein or Andorra, have nothing to gain from raising their tax-levels in order to reduce negative policy externalities.

Regarding innovation policy, the nature of policy externalities differs with the kind of market failure that a policy is concerned with. A subset of the market failures discussed in Section 2.1 can lead to policy externalities:

- Knowledge diffusion
- Buyer surplus
- Inefficient standardisation

[14] In case of positive externalities it is more appropriate to refer to a 'free-rider' problem.

Knowledge diffusion. Three forms of knowledge diffusion have been mentioned in Section 2.1.1: imitation in markets not served by the innovator, imitation by competitors and applications of innovations unintended by the innovator. The policy externality induced by the first kind of diffusion, imitation in other markets, can in principle be solved by policies promoting economic integration, like reducing barriers to trade and investment. Policy cooperation in the field of IPR protection can reduce this externality as well.

As there is little incentive for individual Member States to prevent imitation by domestic firms from foreign companies, also the presence of imitation offers a scope for supra-national policy. If countries are similar in terms of the relative incidence of imitation by domestic firms, both centralisation of policy and cooperation regarding the protection of intellectual property can provide a solution to the prisoner's dilemma. When some countries benefit more from imitation than others do, there is an incentive to avoid or frustrate agreement.

Also diffusion of knowledge leading to unintended innovations brings about a policy externality. Individual Member States do not have an incentive to promote the diffusion of knowledge across national borders, which results not only in a slower diffusion of knowledge within the EU, but also in a bias towards domestically oriented industries. This kind of policy externality can be internalised by promoting economic integration, in particular by removing barriers to knowledge diffusion across borders.

Surplus of foreign buyers. National policymakers that would like to reduce market failure due to buyer surpluses face a free-rider problem, in particular for innovations applied in high-trade sectors. Suppose a subsidy on R&D-expenditure is given to a firm in order to stimulate innovation, then part of the benefits of the subsidy will accrue to customers of the firm in other countries. In an integrated European market, there could be an incentive for Member States to reduce or abolish subsidies to R&D while still profiting from the innovations subsidised by other countries. Centralisation and cooperation can be used to internalise this policy externality.

Inefficient standardisation. As standards are typically intended for use in several countries – if not for use world-wide – a free-rider problem will arise if countries are unwilling to cooperate on policies promoting efficient standardisation. Supra-national organisations like the EC therefore seem better suited for monitoring and facilitating the development of standards by SSOs and private companies than individual Member States are.

3.3 Heterogeneity

The previous two sections have provided an array of arguments in favour of centralising innovation policy at the European level. However, centralisation also has its cost. Keeping innovation policy at the national level has three potential benefits (Pelkmans (2006) and Ederveen et al. (2006)):

- Adaptation to local circumstances,
- Learning from a diversity of experiences and
- Better incentives for policymakers through policy competition.

In the context of innovation policy, local circumstances are important not just because preferences tend to differ from one country to another, but also because of differences in innovation systems. Carlsson (2006) concludes from a literature survey that although national innovation systems are internationalising, they still require support from national institutions. Foray (1995), for instance, argues that intellectual property rights regimes are so closely linked with innovation systems that standardisation of these regimes would cause a reduction in the diversity of those systems. Diversity in innovation systems would be important, according to him, because it positively contributes to scientific and technological change.

A second benefit of decentralisation also has to do with maintaining diversity. Governments adopting different innovation policies can learn from each other which policies are the most effective. While centralisation leads to a complete loss of diversity within the EU, a degree of diversity is still possible in case of multilateral cooperation.

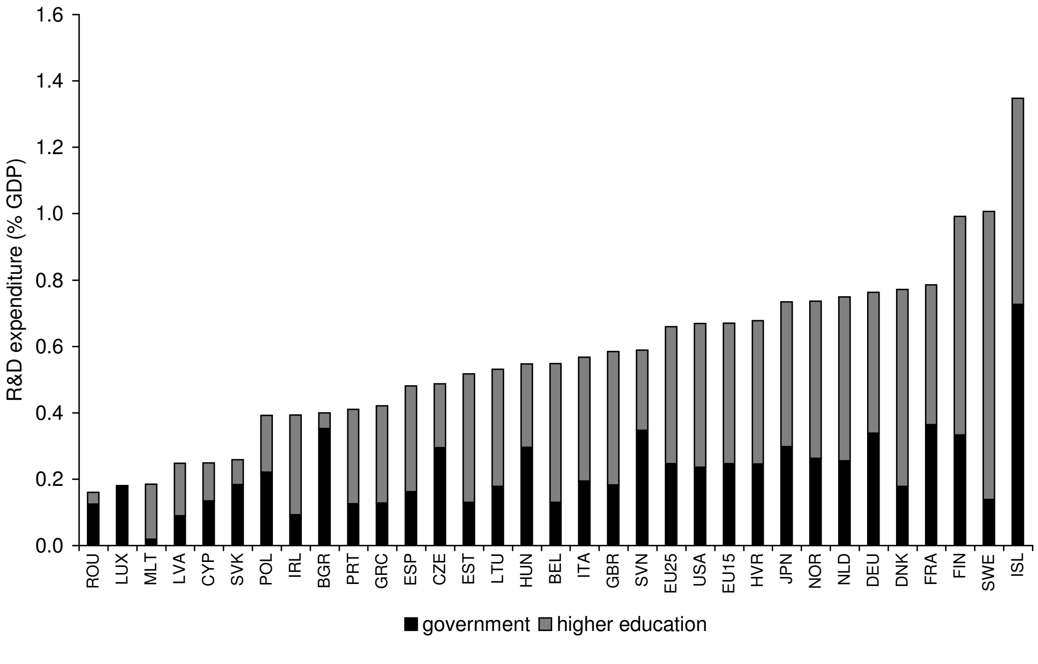
Greater accountability of policymakers is a third potential benefit of decentralisation. Tiebout (1956) presents a theoretical model in which policy competition arises because voters can migrate from one region to another (see also Pelkmans (2006)). Instead of voters, also multinational companies may trigger policy competition. Member States with a more effective innovation policy might attract more foreign investment, such that underperforming Member States will be under pressure of adjusting their innovation policy. The availability of benchmarks from other Member States provides an additional incentive for policymakers to improve.

4 Public investment in R&D

Public R&D is the most direct form of innovation policy that one can imagine. Both the funding and execution of R&D are performed by the government. As such, it can be distinguished from public funding of private R&D, which will be the subject of Chapter 5. Public R&D encompasses research and development by publicly owned enterprises like hospitals and by defence among others. We include research at public universities (or by higher education in general) in public R&D as both the expenditure and execution is governed by the government.

Figure 4.1 gives an overview of the structure and magnitude of public expenditure on R&D. Remarkably, the United States and Japan are very close to the EU average – not only for total public expenditure but also for government expenditure and higher education expenditure individually. Figure 4.1 shows that in Finland and Sweden no less than 1% of GDP is spend by the government on research and development, while it is only 0.2% of GDP in Luxembourg and several new Member States.

Figure 4.1 Public R&D expenditure in the EU is comparable to US and Japan (2003)



Source: Eurostat; a list of country codes is provided in Annex A

Why does the government participate in R&D instead of passing it over to the market? The most immediate answer to this question is that public research is not a perfect substitute for private research as public R&D is less susceptible to market forces. This is not just a disadvantage: the insensitivity of public R&D to markets enables a freer exchange of knowledge than is the case for private R&D, at least if the knowledge developed by public

R&D is publicly available. This holds for example for basic science, but less for defence-related public R&D. Freer diffusion of knowledge makes public R&D more likely to benefit from increasing returns to scale than private R&D.

4.1 Scale economies

Public research is subject to the same kind of scale economies as private research, a topic which has been discussed in Section 2.1.6. First, scale economies can arise from the presence of fixed cost. Some research projects are too large and risky to be undertaken by a single country. Multilateral cooperation then enables R&D projects that would otherwise not have been undertaken. A concrete example of a large European public R&D project is the Galileo satellite navigation system, which is a joint venture of the EC and the ESA with a budget of several billions of Euros.

A second type of scale economies stems from the internalisation of externalities. Not only the policy externalities introduced in Section 3.2 are relevant here, but also some of the externalities for private research described in Section 2.1. In particular, European coordination of public research can improve the diffusion of knowledge between countries, thereby establishing a larger knowledge base with more specialised researchers and less duplication of research (Section 2.2.2).

A larger scale of the economy fosters competition between researchers and induces specialisation among them. This improves their productivity and warrants a larger share of public spending in larger countries if knowledge would not diffuse to abroad. Whether the scale of the domestic economy really matters, depends on the openness of public R&D institutes and universities. An internationally oriented university, for example, will employ specialised researchers from various countries who publish in international journals *even* when this university is located in a small country. In the related area of higher education (not research in higher education, but education itself), Thissen and Ederveen (2006) show that scale economies are absent.

The risk of duplication in research matters for public just as for private R&D. In both cases it leads to overinvestment in R&D, to which international coordination might be an answer. For R&D in general, Jones and Williams (2000) investigate the impact of this duplication- and other effects to show whether there is too much or too few R&D. They start with a theoretical model in which several market imperfections are integrated – some leading to too much R&D, others imply to too few. Their application is, however, hampered by the lack of empirical evidence on size and impact of each element. They conclude that countries typically invest too little in R&D, which points at the importance of positive externalities like knowledge spillovers. In addition, they show that countries only invest too much in R&D in the exceptional case where the *stepping on toes effect* (duplication) is very large.

University-industry relations: Does the European knowledge paradox require a European solution?

Compared to the United States, collaboration between universities and private companies is rather scant in European countries. This lack of collaboration is remarkable considering that European universities are quite productive in terms of high-quality output. The combination of high scientific productivity with little knowledge exchange between the public and private sectors has been coined the *European knowledge paradox*. In a recent report, Canton et al. (2005) propose five types of public policy that should stimulate the spillovers between public and private research:

- Provide incentives for scientists to engage in university-industry interaction
- Provide preconditions for entrepreneurship in academia
- Improve the match in research activities
- Increase absorptive capacity of private firms
- Be ‘intelligent’ with venture capital for private firms

The first two points are concerned with the functioning of European universities in comparison with the US. The Bayh-Dole act in the US allows universities to patent and share the subsequent revenues with inventors, which has greatly encouraged scientists to bring their inventions to the market. In addition, many US universities have Technology Transfer Offices (TTOs) that aid researchers with commercialisation of their inventions. Similar policies could be introduced in Europe, but there are no obvious scale effects or externalities that would warrant European coordination. However, the conditions applying to public research funded by the EC can be adapted to facilitate public-private cooperation.

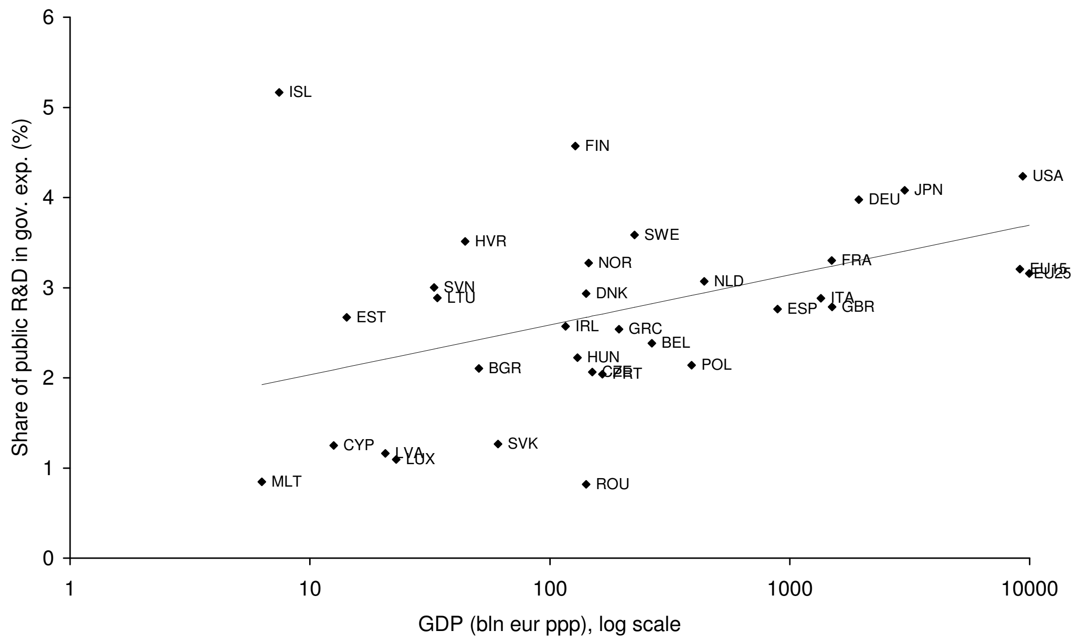
The last three points refer predominantly to public funding of private research. For example, thematic funding of public-private research projects can help to close the gap between the research agenda’s of universities and companies. Public funding of private R&D can also improve the absorptive capacity of firms, thereby enabling them to better benefit from public research. The report further advocates the use of independent experts for allocating publicly funded venture capital. Whether European coordination is desirable for public funding of private R&D or venture capital is discussed in Chapters 5 and 6, respectively.

An alternative reason for duplication of research is that governments may spend some minimum amount on public research just in order to maintain some knowledge in various fields of science. This argument is especially relevant for smaller countries, like Malta and Cyprus.

The evidence on the relative size of each of the scale effects is still very limited. We hypothesise that international knowledge spillovers, which make it difficult to appropriate the return to R&D, dominate the duplication effect and lead to underinvestment in public R&D. These scale effects will be particularly important for small economies – larger economies are able to internalise a larger share of the return to R&D. This line of reasoning implies therefore that the GDP-share of public R&D increases with the size of an economy.
Figure 4.2 illustrates the existence of scale economies in public R&D. The figure contains a scatter plot of the relative size of public R&D on the vertical axis against the size of the economy measured in terms of GDP. The relative size of public R&D is measured as the share

of public R&D expenditure in total government expenditure.[15] The absolute size of GDP is measured in billions of euros purchasing power parity (ppp).[16] The horizontal scale is logarithmic because the differences between countries increase with the level of expenditure. A regression-line has been added based on OLS-estimation. There appears to be a positive association between the scale of the economy and the amount of public R&D.[17] A country, say France, which is ten times (in terms of GDP) than another country, say Ireland, has on average a 1%-point larger share of public R&D in government spending. The exceptions to the rule that larger countries spend relatively more on R&D are also clearly visible from Figure 4.2: despite their limited scale Scandinavian countries like Finland, Sweden and Iceland spend relatively much on public R&D.

Figure 4.2 Economies of scale in public R&D (2003)



Source: Eurostat; a list of country codes is provided in Annex A
EU 15 and EU 25 have been omitted from regression.

Economies of scale provide a likely explanation for the pattern found in Figure 4.2. Large countries may internalise a larger share of the return to public R&D, which induces them to spend relatively more on public R&D. If the efficiency of R&D expenditure indeed increases with its scale, this relation should not only be present for public R&D but also for private R&D.

[15] Alternatively, the share of public R&D in GDP can be used. This would reduce the vertical gap between the EU and the USA. The share of public R&D in government expenditure has been chosen in order to take into account heterogeneity in preferences for the size of government across countries. If the inhabitants of a country tend to have an appetite for a small government it is likely that a larger part of R&D expenditure will come from private sources. In particular, a lot of fundamental research in the USA is privately funded.

[16] Other indicators of scale like the size of the working population of the absolute size of public R&D reveal similar patterns.

[17] The coefficient is 0.0024 with a heteroscedasticity robust standard error of 0.0012. Number of observations is 31.

Indeed, as Figure 2.1 has already shown, a scale effect is visible for private R&D expenditure as well.

A tentative conclusion, which may be drawn from Figure 4.2 is that the European Union has some potential to exploit the scale economies in public R&D. Its share of public R&D in government expenditures are below the regression line, let alone the gap with the United States. The European Union might be able to internalise a larger share of the return to R&D than each individual Member State. Section 4.2 focuses on one important source for scale economies: the internalisation of cross-border externalities.

4.2 Externalities

The presence of cross-border externalities may limit the benefits of public R&D for the domestic country, which is the second motivation for European coordination of public R&D expenditure. There are several reasons why public R&D benefits not only the home country, but other Member States as well. The most prominent reason is knowledge diffusion across borders.

Section 2.2 has shown for private R&D that neighbouring countries benefit from the diffusion of knowledge. For knowledge developed via public R&D this diffusion might be even stronger, as the resulting knowledge is often publicly available. International diffusion might even be an aim of public R&D, in particular for scientific research (see box *The two objectives of public research*). Despite this explicit goal, the presence of international leakages reduce the incentives for internationally oriented (open) countries to invest in public R&D. Open countries can quite easily acquire knowledge abroad, but benefit to a relatively small extent from own research.

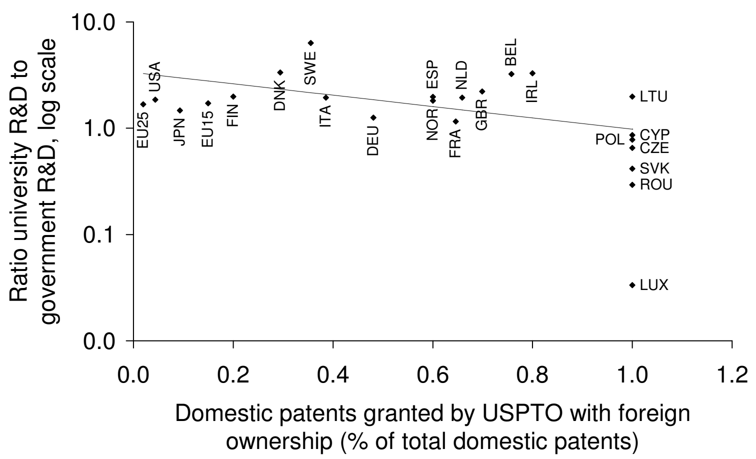
This line of reasoning presumes a positive impact of public R&D on private sector performance, not only at home but in foreign countries as well. Part of the empirical literature on the economic impact of public R&D indeed supports this view. A recent review noted that "attempts to calculate the returns to public research have generally resulted in high rates of return, from 20 to 50% and higher" (Scott et al. (2002)) This contrast, however, sharply with the observation of the OECD (2003) that output growth is positively related to private R&D, but not to public R&D. This finding can be due to the fact that cross-border diffusion of knowledge weakens the relation between *national* GDP and *national* public R&D. Another possible explanation for the result is that publicly performed R&D may be 'crowding out' resources that could alternatively be used by the private sector, so that publicly funded R&D is displacing private investment in science and technology.

The two objectives of public research

Public expenditure on research is not exclusively the domain of innovation policy. Besides enhancing the economic performance, the pursuit of knowledge can also be an objective by itself. The two objectives of public research are reflected in the direct expenditure on R&D by government institutes and the expenditure on research performed at universities. The government institutes have the objective of supporting sectors of the domestic economy, whereas universities are traditionally more concerned with discovery for its own sake – although European universities are increasingly urged to perform R&D directly useful for the private sector (see previous box *University-industry relations*). The different perspectives on the role of public research imply a different attitude towards the diffusion of knowledge to other countries. Government R&D intended to support local economic activity is not actively diffused abroad because it is generally tailored to local needs and because it should not benefit foreign competitors. Universities, in contrast, see international dissemination of knowledge as essential to their performance. In particular, the status and rewards of researchers at universities depend on publications in internationally read scientific journals. University research is therefore more likely to result in international diffusion of knowledge than government R&D.

What are the consequences of the dual objectives of public R&D on the presence of policy externalities? Government R&D is likely to be confined to areas with a low probability of knowledge leaking abroad. For these areas, expenditure on government R&D will not be affected by a policy externality. For other areas of research, the risk of knowledge leaking abroad reduces the incentive for government R&D and leads to a policy externality. The 'idealistic' objective for the funding of university research suggests that policy externalities are less likely to occur here. Governments would have fewer problems with the strong international diffusion of university research if its primary objective is the pursuit of knowledge. In order to see whether the objectives of public R&D matter for the presence of policy externalities, we have plotted the ratio of expenditure on university R&D to government research against foreign patent ownership. For most Member States the R&D ratio lies just below two, except for the extremely open countries like Luxemburg where the ratio is much smaller. The R&D ratio for the EU is similar to that of the USA and Japan, which suggests that the influence of the extremely open countries is negligible. In general, we can conclude that expenditure on university R&D tends to respond in the same way to leakage of knowledge as government R&D. Both types of research are equally vulnerable to policy externalities – with possibly an exception for countries where leakage is extreme. For these countries, expenditure on university research is relatively small.

Do the objectives of public research matter for policy externalities?



Source: Eurostat; a list of country codes is provided in Annex A
Luxemburg, EU 15 and EU 25 have been omitted from regression.

Even at the regional level, a strong influence of public R&D (generally by universities) on the business sector cannot be robustly observed. According to Zucker et al. (1998), proximity with public labs and universities is of no use for improving innovation. A more recent study by Ronde and Hussler (2005) observe a positive, but still moderate impact. Empirical studies point, however, at the presence of positive effects if deliberate interactions with scientists are undertaken.

One might hypothesise therefore that international diffusion of knowledge causes small and open economies to spend relatively little on public R&D. The relation regarding the size of the economy has been confirmed in the previous section. A straightforward way of verifying whether cross-border externalities affect public expenditure on R&D is to test if public R&D is negatively associated with the openness of Member States. In open economies it can be expected that the benefits of public R&D are more likely to 'leak' to other countries than in closed economies. Therefore governments of countries with an open economy might be less inclined to spend on R&D.

In this context, we have used the proportion of patents on domestic inventions that is owned by foreigners as an indicator of openness. In order to ensure international comparability, the proportion of foreign-owned patents is based on patents granted by the United States Patent and Trademark Office (USPTO). Figure 4.3 shows a rather pronounced negative association between public R&D expenditure and the proportion of patents owned by foreigners.[18] Remarkable is the extremely high proportion of foreign ownership for the former communistic countries. After the Iron Curtain was drawn western multinationals en masse patented inventions that were not accessible to them before.

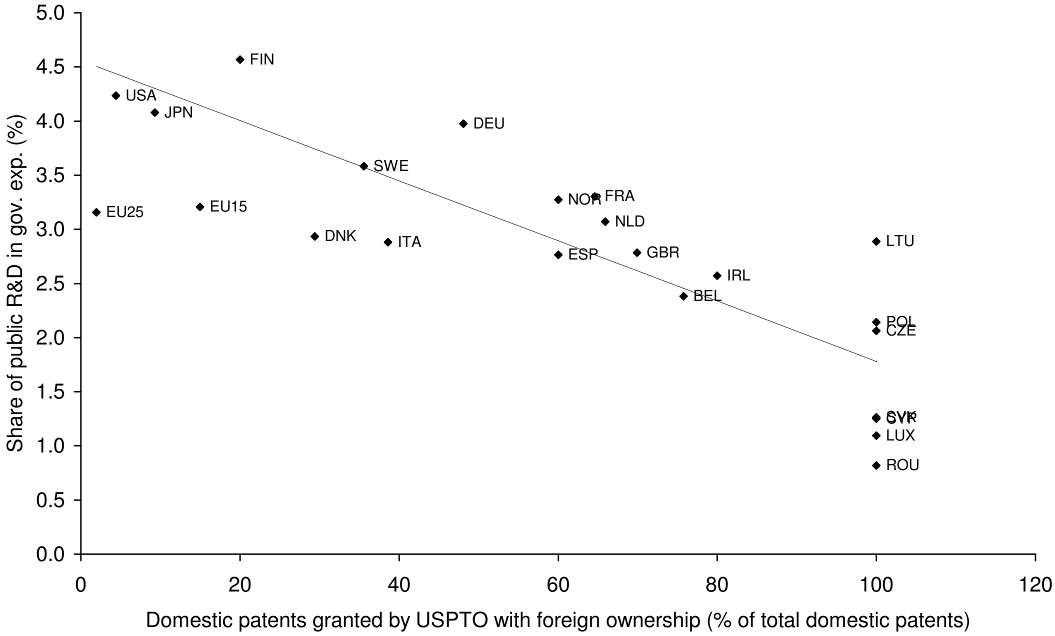
The negative association between public R&D expenditure and foreign ownership of patents suggests that governments are indeed sensitive to 'leakage' of benefits from public R&D to abroad.[19] The leakage is larger at the Member State level (also for larger countries) than for the EU as a whole, because the leakage between EU Member States remains within the EU.

The share of expenditure on public R&D in the EU is small compared to the US and Japan – possibly as a result of a free-rider problem in the EU. Assuming the association between relative expenditure on public R&D and the share of foreign-owned patents reflects a causal relation, centralising public expenditure on R&D at the European level could raise the EU budget for public R&D to a level comparable to that of the United States or Japan.

[18] The coefficient on the share of foreign-owned patents is -0.0278, with a heteroskedasticity robust standard error of 0.004 and an adjusted R^2 of 0.71. Number of observations is 21. Excluding countries for which more than 95% of all patents are owned by foreigners yielded a coefficient of -0.0214 and a standard error of 0.004.

[19] This effect should not be overstated, though, as the similar analysis for the relation of public R&D with the share of high-tech export in GDP does not confirm this negative relationship between openness and public R&D.

Figure 4.3 Public R&D is negatively related to the share of foreign-owned patents (2003)



Source: Eurostat; a list of country codes is provided in Annex A

EU 15 and EU 25 have been omitted from regression.

As openness and scale are negatively related,[20] it is possible that the apparent effects of scale could merely reflect openness or vice versa. Regression analysis, which is available upon request, offers a possibility to distinguish between the effects of scale and openness. Adding the share of foreign-owned patents to the log of GDP as explanatory variable of public R&D expenditures leads to a reduction in the coefficient on log GDP. The coefficient on scale becomes statistically insignificant, whereas the coefficient on openness remains significantly negative. This suggests that the scale effect merely reflects the effects of cross-border externalities represented by foreign share-ownership.

4.3 Heterogeneity

All three arguments for heterogeneous national policies discussed in Section 3.3 apply to public R&D. First, at least part of public R&D tries to solve local problems, like research for dike construction in the Dutch province of Zeeland. This does not exclude, however, the possibility that this knowledge spills over to other countries, like to New Orleans in the United States or Venice in Italy. Still, it limits the scope for European coordination, as most other Member States are much less interested in dikes. Second, heterogeneity allows different governments to

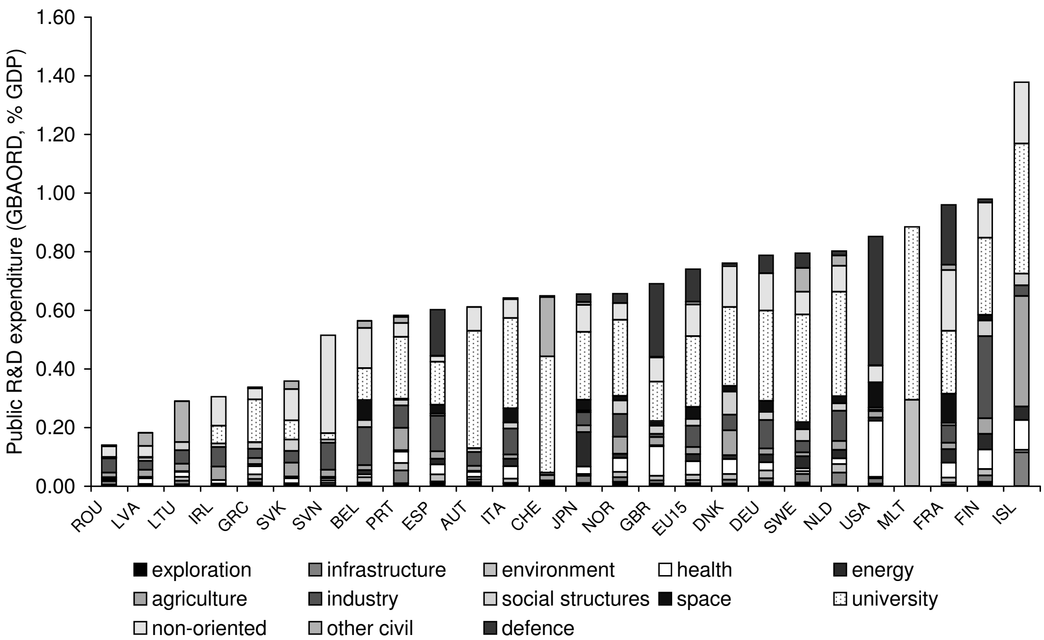
[20] An additional regression shows that the coefficient of foreign-owned patents on the log of public R&D expenditure is -5.06, with a standard error of 0.79 and an adjusted R^2 of 0.64. If high-tech exports are used as a measure for openness instead of foreign patent, the statistical relations with public R&D expenditures is not significant.

seek for different answers to similar problems. This facilitates the learning from each other. Third, diversity in public R&D may in the long run lead to the most efficient type of R&D. In particular, if multinationals are among the recipients of the public innovations, governments may be induced to seek for the highest efficiency in public R&D.

Public R&D differs from country to country; some spend a lot, others spend a bit (Figure 4.1). However, for the question of subsidiarity also the composition of public R&D matters. An indication of the variety in composition is provided by Figure 4.4, showing the socio-economic objectives of government expenditures on R&D in a selection of OECD countries for which these data are available.

At first sight, the figure clearly points at significant heterogeneity in the objectives of public R&D. Part of this heterogeneity can be explained from the industry structure of the countries. Public R&D is aimed at activities or sectors in which a country is 'large'. In industrial countries like Germany and Japan, a lot of public R&D expenditure is focused on industrial production, whereas Denmark and Portugal spend higher fractions on research oriented towards agriculture. For the Netherlands, the presence of an agricultural university (currently renamed as the leading European university in the life sciences) in a historically agricultural country and the presence of a university of technology in the industrial city Eindhoven illustrates this relationship.

Figure 4.4 Heterogeneity in socio-economic objectives of public R&D expenditure (2000)



Source: Eurostat; a list of country codes is provided in Annex A

The category "university" does not correspond to the category "higher education" of Figure 4.1.

Specialisation of public R&D in domestically large sectors maximises the domestic return and minimises the leakage of knowledge to other countries. It reduces therefore the need for European coordination. In addition, the mere presence of heterogeneity reduces the scope of European involvement in public R&D.

4.4 Subsidiarity in public R&D

There are many theoretical arguments supporting scale effects in public R&D and we have found some empirical indications that larger countries spend relatively more on R&D. Our (regression) analysis suggests that a major source of scale effects is the internalisation of policy externalities stemming from the diffusion of knowledge across borders. European coordination of expenditure on public R&D alone could provide sufficient incentives for Member States to spend relatively the same amount on public R&D as Japan and the US. The fact that countries are inclined to spend more public R&D towards relatively large sectors in the economy supports this conclusion. The heterogeneity across countries in the socio-economic objectives of R&D, however, could hamper European coordination of public R&D.

We conclude that European coordination of public R&D could be beneficial because policy externalities seem to hamper spending on public R&D. If the Member States of the European Union agree to increase expenditures on public R&D, all Member States could benefit. The European Commission should also be involved in public R&D projects where the scale really matters – such as the ITER-programme on nuclear fusion – and to basic science where international specialisation is important. This does not imply that all public R&D should be performed by the European Commission. Given the differences in national socio-economic objectives on public R&D it seems reasonable that the Member States themselves determine to their objectives to some extent. There the role of the European Commission could be limited to facilitate an agreement on increases in R&D spending – like the Lisbon targets – and to monitor Member States progress. National action plans seem to be a good format for this.

5 Public funding of private R&D

A second type of innovation policy is government funding of private R&D, which includes direct subsidies and tax credits. Its size is quite limited in most European countries, ranging between less than 0.1% of government expenditures in a couple of new Member States to 0.6% in Great Britain, France, Sweden and Germany. Quite remarkable is the large share of public funding in the United States of more than 1% of the government budget, mainly attributable to innovation by private firms for the US Department of Defence.

The current chapter investigates whether public funding of private R&D should be coordinated at the European level. Before, it should be notified that the outcomes of econometric research on the usefulness of public funding are ambiguous. The key question is whether public funding complements or crowds out private expenditure. Just counting empirical studies, García-Quevedo (2004) shows that about half of the empirical studies (38 out of 74) point at complementarity, in which public funding really increases total expenditure on private R&D. However, the remaining studies either point at substitutability (17 studies), in which public funding crowds out private expenditure, or find no relation at all (remaining 19 studies). After an extensive meta-analysis, García-Quevedo concludes that "(t)he econometric evidence on the relation between public funding of business R&D and private R&D expenditure is ambiguous."[21]

A useful distinction in the public funding of business R&D is between tax credits and direct subsidies.[22] The primary difference in execution between these two policy instruments is that the former typically allows the private firms to choose projects, whereas the latter usually is accompanied by a government directed project choice. David et al. (2000) argue that tax credits are likely to favour projects that will generate greater profits in the short run, rather than projects with high social rates of return. Direct subsidies seem more appropriate to stimulate projects with high social rates of return, and are therefore less likely to crowd out private investments. The data used in this Chapter refer to direct subsidies and public procurement, and do not include tax-credits.

5.1 Scale economies

According to Figure 2.1, there are some indications for economies of scale in private R&D. These are relevant for the question whether public funding of private R&D needs European coordination: if a private research project has a multinational character, funding by a single country could be inadequate. In such a situation several countries could individually contribute or a single country could handle the project, passing the bill to other countries.

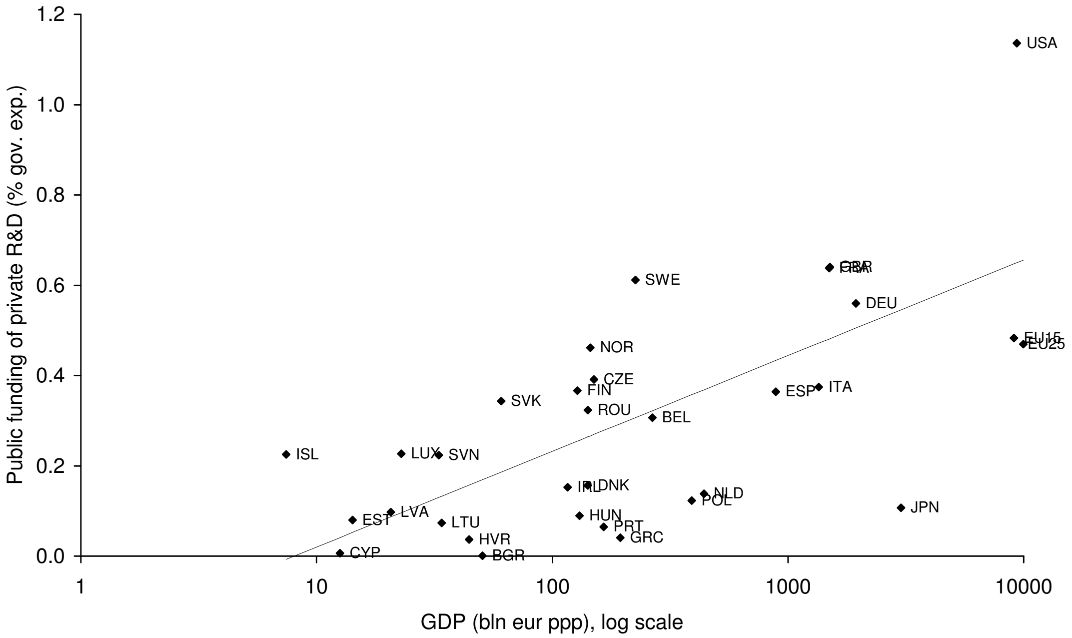
[21] See David et al. (2000) for a similar conclusion from a review of the econometric evidence.

[22] Tax credits are usually not included in the statistics on private funding. Conceptually, however, they belong to it, being a financial stimulus for private R&D.

Less likely are economies of scale in the public administration of R&D subsidies or tax credits. Tax credits are fiscal instruments which should be incorporated in the national tax systems. Direct subsidies are likely to be targeted at specific projects or particular firms. Only if the scale of these projects or firms cross the national borders may scale economies play a role.

In an attempt to measure scale economies we plot the share of public funding in total government expenditure plotted in Figure 5.1 against the scale of the economy in terms of GDP.[23] Note that we have to ignore the role of tax credits in stimulating innovation here because lack of data, although the size of these credits could be substantial.

Figure 5.1 Economies of scale in public funding of private R&D (2003)



Source: Eurostat; a list of country codes is provided in Annex A.
Public funding only comprises direct transfers, not tax credits.
EU 15 and EU 25 have been omitted from regression.

A positive association between public funding of private R&D and the scale of the economy is clearly present.[24] Also striking is the fact that public funding is much more important in the United States than in Japan. A possible explanation for this the outsourcing of R&D by the US Department of Defence to the business sector and the presence of large conglomerates (*keiretsu's*) in Japan, which possibly reduces the need for government funding. Within Europe, the three largest countries, Germany, the UK and France, spend a relatively large share of the

[23] Alternatively, the size of private R&D could be used as measure of scale. The resulting picture would again point at the presence of economies of scale.

[24] The estimated coefficient between log GDP as measure for scale and public expenditure on private R&D is 0.0009. The heteroskedasticity robust standard error is 0.0003 and this explains 39% of the variation in the data. The number of observations is 30.

their budgets to the public funding of private R&D. Relative to its size, the Netherlands spends less public funds on private R&D than most other countries.

5.2 Externalities

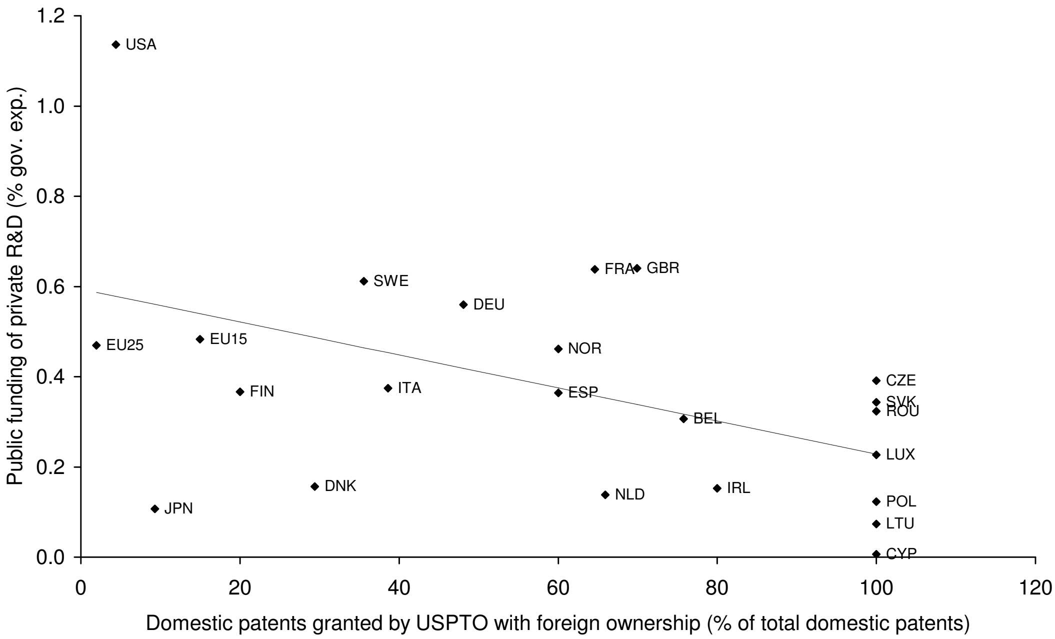
Cross border externalities are significant in private R&D, see Section 2.2. In particular, the impact of R&D on foreign productivity is significant (Keller (2004)), though the evidence on foreign patents are less clear cut (Jaffe et al. (1993)). These externalities likely matter for the public funding of private R&D, insofar national governments stimulate foreign productivity.

Externalities may also play a role in the subsidy or tax credit itself, in particular if these public funds accrue to internationally operating firms. The risk that multinationals use the subsidy to fund R&D in foreign affiliates causes governments to impose the condition that the subsidy is used locally, which increases the regulatory burden and reduces the opportunities to subsidise.

These considerations lead to the expectation that governments in open economies spend relatively less on R&D subsidies or tax credits. The empirical support for this thesis is, however, surprisingly weak. Figure 5.2 shows a weakly (not statistically significant) negative relation between the share of public funding in total government expenditures and the share of foreign-owned patents. Even less significant is the same picture with the share of high-tech exports as a measure of openness. This suggests that internalisation of possible cross-border externalities is not a significant source for the economies of scale pointed out in Section 5.1.

This lack of evidence for externalities in public funding of private R&D might have several explanations. First, governments are able to target their funds to domestically oriented firms. Second, the outcome of public research is more likely to cross a country's borders than is the case for private R&D, as private firms try to protect their innovations. Third, private R&D tends to be larger in open economies (with a large share of high-tech exports). Ceteris paribus, this leads to more public funding in open economies, which at least partially offsets the hypothesised negative relationship.

Figure 5.2 Public funding of private R&D is negatively related to share of foreign-owned patents (2003)



Source: Eurostat; a list of country codes is provided in Annex A
EU 15 and EU 25 have been omitted from regression.

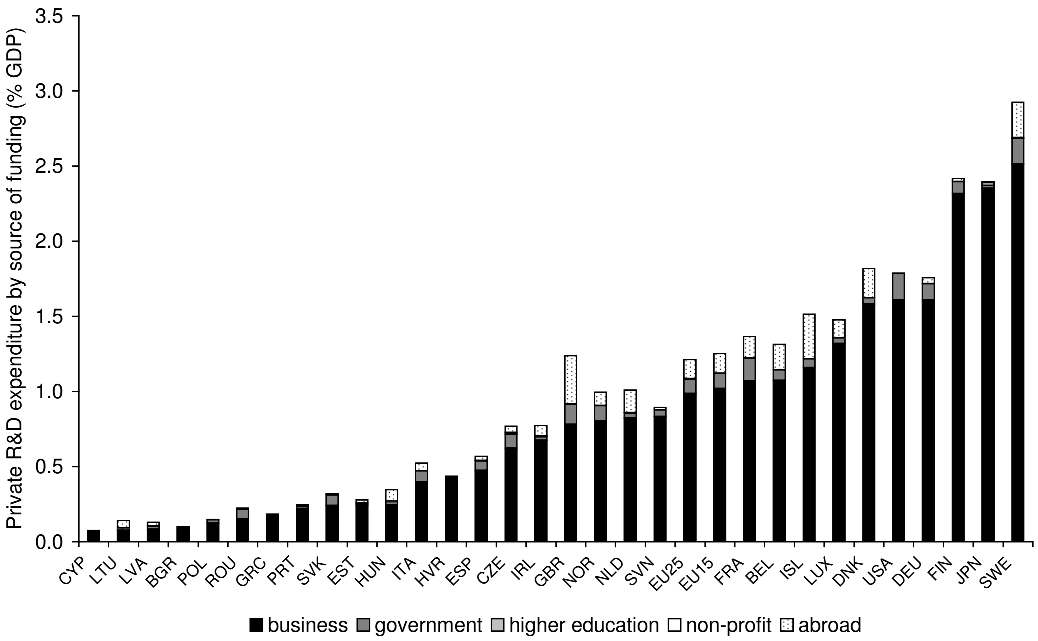
5.3 Heterogeneity

How heterogeneous is the public funding of private R&D? One measure of heterogeneity is the socio-economic objective of the public funds. Figure 4.4 has shown the great diversity in the total public expenditures on R&D. Unfortunately, the total expenditures are not subdivided in public funding of private R&D and public funding of public R&D, but it is likely that a similar heterogeneity as in Figure 4.4 also holds for this public funding of private R&D. For example, Abramovsky et al. (2004) conclude from an analysis of the Third Community Innovation Survey (CIS 3) results that a large part of heterogeneity in innovation behaviour can be explained by differences in the relative importance of industries. Mohnen et al. (2006) confirm the heterogeneity in private innovation, but dispute the explanation from industry heterogeneity. They conclude that a large part of the variation in innovation across seven European countries remains difficult to explain using micro-aggregated data from CIS 1.

A second difference between countries is the design of public funding, for example in the way firms have to apply for these funds. Already mentioned is the distinction between subsidies and tax credits. Policies may also differ in the open character of their funds. On one side, firms may have to compete for the available funds (like in the American SBIR program). At the other extreme, governments may choose to subsidise a single firm without allowing other firms to apply.

Finally, countries differ significantly in the amount of sources they devote to the funding of private R&D, as has already been discussed in the light of Figure 5.1. This point is reinforced in Figure 5.3, which displays the composition of private R&D by sector of funding. Two immediate conclusions can be drawn from this figure. First, the variation in private R&D is even stronger between countries than it is for public R&D. Second, government funding is rather unimportant compared to the funding by businesses themselves.

Figure 5.3 Small share of private R&D expenditure depends on public funding (2003)



Source: Eurostat; a list of country codes is provided in Annex A
The shares of "higher education" are negligible.

5.4 Subsidiarity in public funding of private R&D

Scale economies do seem to be present in the public funding of private R&D: firms in large countries spend more on R&D and are more heavily subsidised, but cross-border externalities do not appear to be the reason for this outcome. The presence of externalities in private R&D substantiates government involvement in general, but it is questionable whether policy externalities cause national support of private R&D to be insufficient. A possible explanation for this finding is that governments normally restrict the use of subsidies and tax-credits to domestic R&D, such that leakage of public funds is considered to be minimal.

The economies of scale are a motivation for greater involvement of the European Commission in the funding of private R&D. One has to be aware that the diversity in type and amount of public funds for private R&D across Member States is large. This justifies a substantial role for national governments in handling this diversity. Greater European involvement could be fine, but priority should remain with national policy.

A different issue is the role of the EU in the Lisbon-goal of spending 3% GDP on R&D. A common goal may ask for coordinated action. Whether a target of 3% is feasible or not, coordinated action provides an incentive for national governments to learn from each other and improve their competitiveness. In any case, the evidence presented in this chapter does not advise against the coordination of the public funding of private R&D, but national objectives should be served by national policies.

6 SMEs, entrepreneurship and venture capital

Innovation is not limited to 'formal' R&D by large companies: often innovation takes place through the establishment of new firms, like during the boom in information technology of the 1990s. European governments have recognised the role of SMEs and entrepreneurship as has been reflected by a wide range of policies adopted in recent years.

Probably the most important of these policies is deregulation. The OECD (2005) notes that regulatory reform is widespread in OECD countries. Reducing the amount of rules that SMEs are confronted with can greatly improve the incentives for running a small firm. In addition, governments can reduce the administrative burden of SMEs through initiatives like e-governance and one-stop-shops.

Governments are also actively involved in making financial resources available to SMEs. This has been done both directly by providing funding to start-up companies and indirectly through regulatory reform beneficial for venture capital. Among the latter type of policies are a more favourable tax-treatment of unlisted stocks, allowing pension funds to invest in venture capital and the stimulation of networks of "business angels".

A third category of SME policies aims to stimulate the diffusion of knowledge among SMEs and between SMEs and universities and other public research institutes. An example of such a policy is the Dutch "Innovation Voucher" experiment. The aim of the experiment was to promote the interaction between SMEs and public research institutes by giving randomly chosen SMEs a voucher for a research project. The experiment was a success in the sense that eight out of ten vouchers led to projects that would otherwise not have taken place (Cornet et al. (2006b)).

Promoting an entrepreneurial spirit is another policy pursued by governments. This involves teaching children at school that self-employment is an alternative career and promoting entrepreneurship is by means of prizes and campaigns.

From the perspective of economic theory, small and medium-sized enterprises (SMEs) deserve special attention in innovation policy for at least two reasons:[25]

- Imperfections in the capital market affect SMEs to a greater extent
- The cost of regulation are relatively high for SMEs

SMEs can have more difficulty in financing R&D than large firms due to problems of asymmetric information (see Section 2.1.6). First, large firms typically are able to finance R&D via an 'internal capital market' from retained profits. Second, large firms have a reputation, while SMEs, especially start-ups, are less well known to potential investors. Governments can

[25] A rather large body of literature exists on the role of SMEs in regional systems of innovation. Recent studies in this area include Asheim (2004), Asheim and Coenen (2005) and Davenport (2005).

alleviate capital market imperfections through loans, subsidies and procurement targeted at SMEs and through encouraging private venture capital.

Connell (2006) emphasises that procurement, rather than venture capital, is vital for the survival of small innovative firms. He makes a distinction between 'soft' companies that do research for customers and 'hard' companies that need venture capital for the production of standardised products. His report describes in detail how the Small Business Innovation Research (SBIR) procurement programme of the United States' government contributes to commercial innovation by 'soft' companies (more on SBIR in the box *Heterogeneity in capital markets for start-up companies* in Section 6.3).

As the cost of regulation is largely independent of firm size, small companies will be disproportionately affected by administrative burdens. Not only will extensive regulation make it more difficult to start a firm, it will also make it more costly to make use of subsidies and other regulation intended to stimulate innovation.

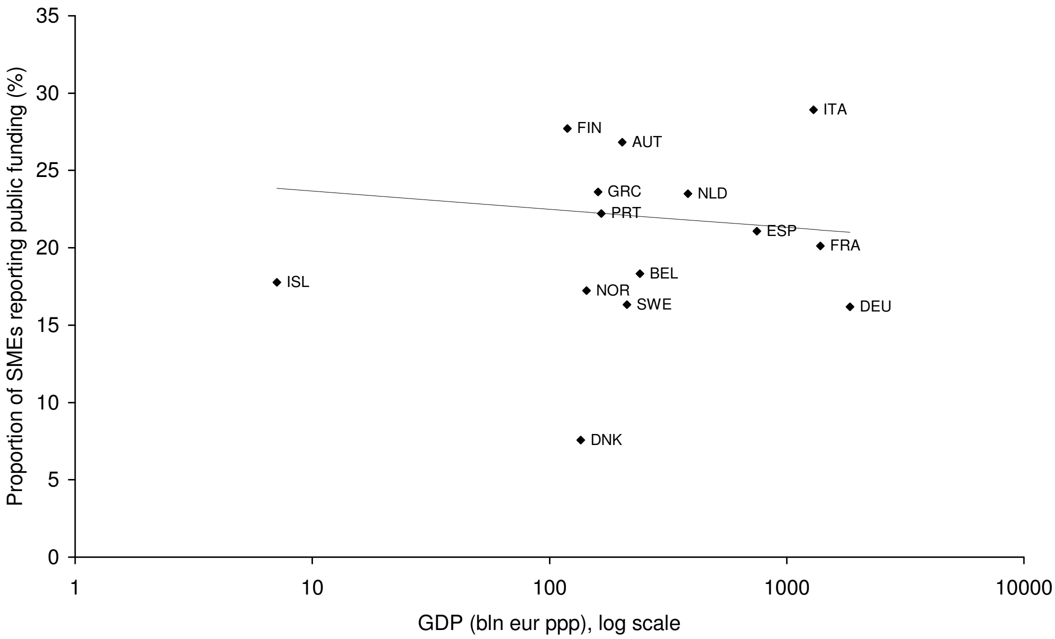
Although there are clear theoretical arguments in favour of innovation policy specifically aimed at SMEs, it is less clear why this kind of policy should be a European rather than national matter. The remainder of this chapter provides a discussion of this issue, focussing on the role of public funding for innovation by SMEs.

6.1 Scale economies

It is difficult to think of scale economies in public administration when it comes to public funding of SMEs. Scale can be somewhat advantageous with respect to the design and execution of policy. Procurement procedures can be handled more efficiently on a larger scale because it reduces the cost of maintaining the expertise of civil servants. However, scale is unlikely to affect the costs of monitoring small and medium-sized firms. Figure 6.1 offers an empirical confirmation of this argument. The figure draws on data from the Third Community Innovation Survey (CIS3), a survey among innovating firms in a number of European countries. In order to measure whether scale matters for SME policy, we have plotted the proportion of SMEs[26] that reported to have received public funding against the log of GDP. If one ignores the small number and proportion of SMEs receiving public funding in Iceland and Denmark, no obvious scale effects appear to be present.

[26] The data on SMEs refer to companies having between 10 and 249 employees that are "innovative". The proportion was computed as the number of respondents answering "yes" divided by the number of respondents answering either "yes" or "no".

Figure 6.1 No scale effects in public funding of innovative SMEs (2000)



Source: CIS3 (Eurostat); a list of country codes is provided in Annex A
Iceland, Denmark, EU 15 and EU 25 have been omitted from regression.

Public funding is not the only method by which governments can enhance the access to capital of SMEs. Better functioning financial markets and venture capital-friendly regulation might prove to be a more effective and efficient way of stimulating innovation than the public funding of SMEs. Governments are unlikely to be as capable in selecting and monitoring promising start-ups as business angels and venture capitalists are (see box *Heterogeneity in capital markets for start-up companies*). In contrast to direct public funding of SMEs, indirect policies offer a better ground for European coordination. For example, harmonised and transparent regulation of Europe's capital markets could contribute to a common European capital market. An increase in the scale of the capital market stimulates innovation as it induces trade in a greater variety of financial products and makes private funds available to business angels, venture capitalist and SMEs.

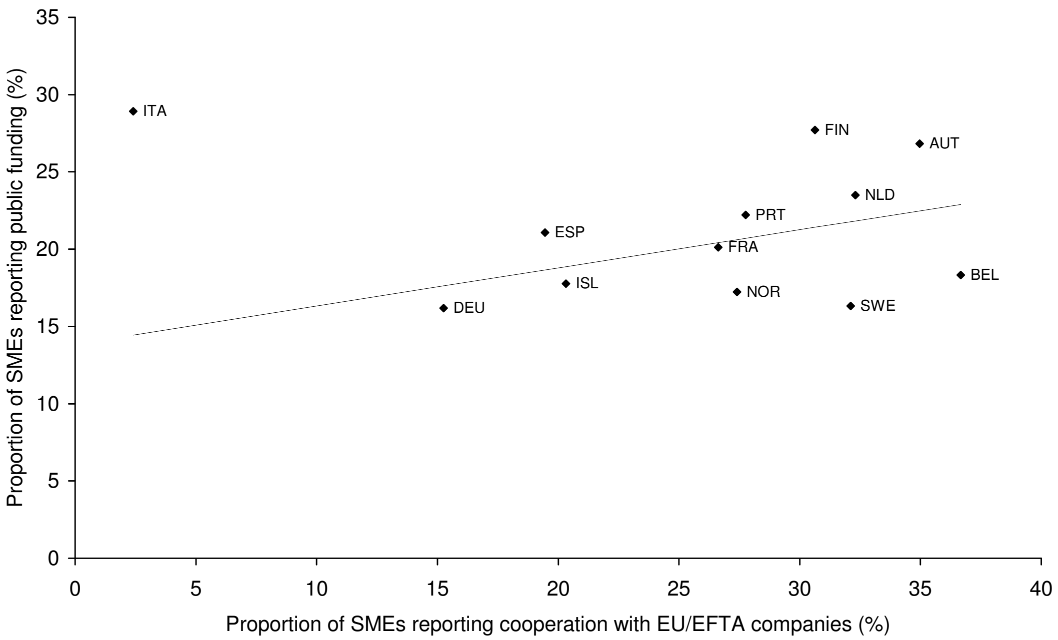
Another possible source of scale economies is European harmonisation of regulation affecting SMEs. If SMEs do not have to invest in learning laws and rules for every new country they want to do business in, it becomes much more attractive for them to export, invest abroad and to cooperate on innovation with foreign firms (Kox and Lejour (2005)). Harmonisation is especially important for SMEs as the administrative burden of doing business in several countries is small for large firms compared to their revenues.

6.2 Externalities

Apparently economies of scale do not exist in government financing of SMEs. As a consequence coordinating SMEs policies at the EU level will also not internalise possible externalities from national policies. This section tests this hypothesis further. In theory governments might be discouraged in supporting their SMEs if they see part of the benefits 'leak' abroad. This can occur if the knowledge generated by an SME receiving public funding spills over to other countries, or if part of the buyer surplus attributable to an SMEs innovation is enjoyed by foreign consumers. The policy externalities induced by knowledge spillovers and foreign buyer surpluses have already been discussed in Chapter 2 and these are not of a different nature when the firms under consideration are SMEs, except for the fact that SMEs are on average more domestically oriented.[27] This implies that policy externalities are likely to be weaker and thus that European coordination will be less useful.

CIS3 provides information on whether innovative SMEs cooperate with foreign firms when they are innovating. Figure 6.2 plots the proportion of SMEs that cooperate with foreign firms located in the EU or EFTA[28] against the proportion of SMEs that received public funding.

Figure 6.2 Cooperation with EU companies unlikely to discourage public funding (2000)



Source: CIS3 (Eurostat); a list of country codes is provided in Annex A Italy has been omitted from regression.

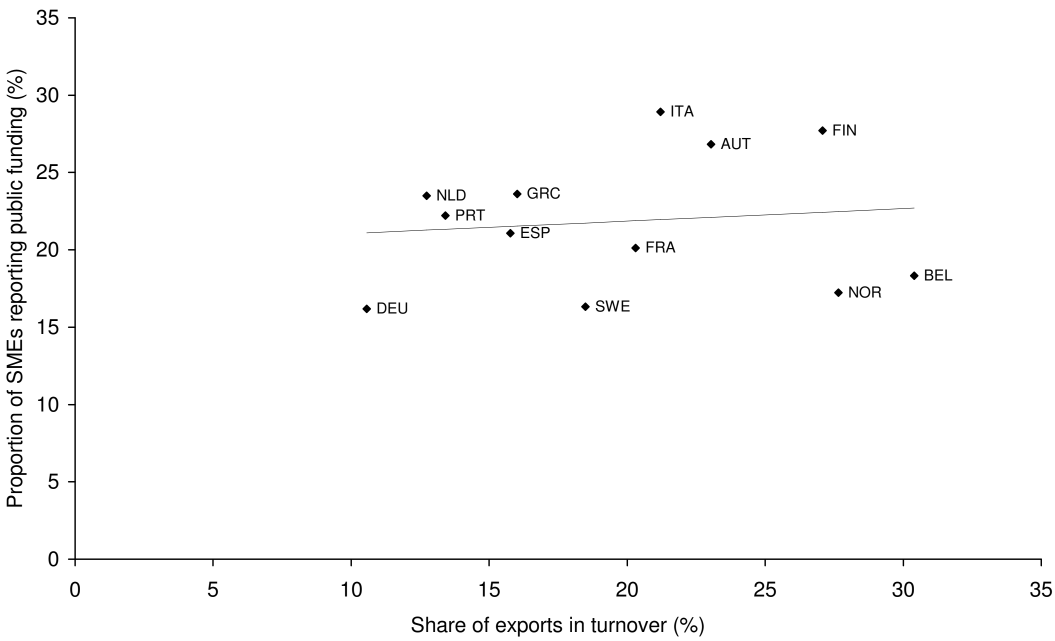
[27] The size of SMEs varies enormously. It includes self-employed but also important exporting firms up to 250 employees. For the latter type of firms the international externalities are much more important on average than for the small firms.

[28] Again the proportion was computed as the number of respondents answering "yes" divided by the number of respondents answering either "yes" or "no".

A positive, but statistically insignificant relation appears to be present between public funding and international cooperation. Countries in which SMEs are more likely to receive public funding – like the Netherlands – also tend to have SMEs that are more inclined to cooperate with firms in other EU or EFTA countries. Apparently, international knowledge spillovers do not seem to discourage public support for SMEs, which implies that those spillovers do no lead to a policy externality.

Next to knowledge spillovers, also the surplus enjoyed by foreign users might give rise to a policy externality. As an approximation for the share of user surplus leaking abroad, we have taken the average share of exports in total turnover for innovative SMEs, which is also available from CIS3. The results are visualised in Figure 6.3. No relation between public funding and exports is discernable in this figure. Rather surprising is that exports do not seem to be important for SMEs in the Netherlands, even though they tend to cooperate with foreign firms a lot while this is the other way around for Italy.[29]

Figure 6.3 No relation export-orientation and public funding (2000)



Source: CIS3 (Eurostat); a list of country codes is provided in Annex A

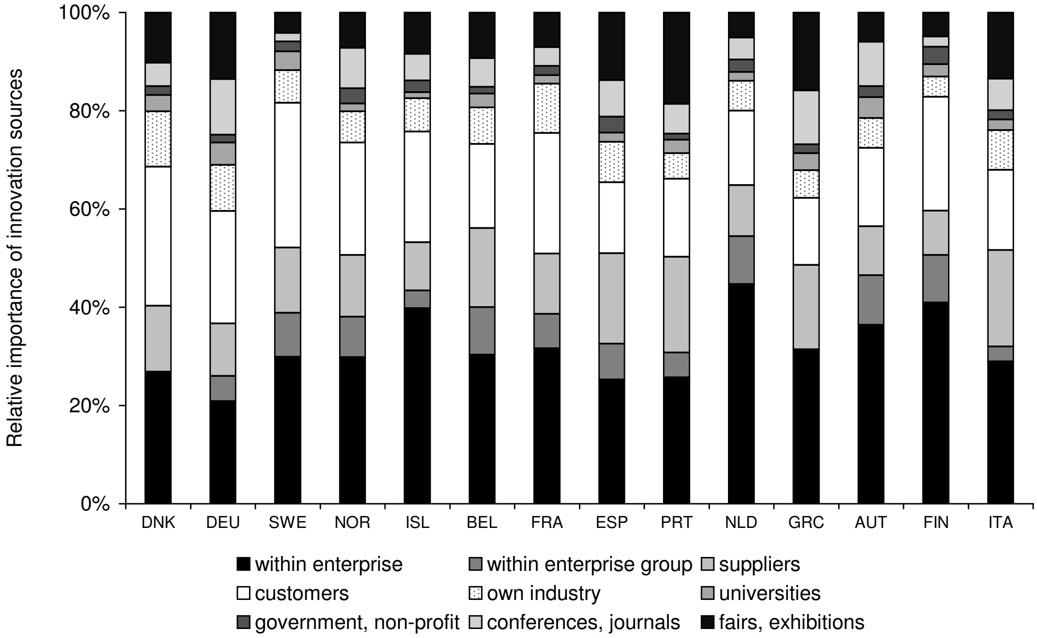
6.3 Heterogeneity

The absence of scale effects regarding innovation policy aimed at SMEs, could be due to different roles played by SMEs in different economies. For example, SMEs could differ from

[29] The outcome might be affected by the sample of firms represented in CIS 3, which is biased towards innovative SMEs. National statistical agencies, however, correct for this bias when reporting aggregate data.

one country to another with respect to the sources for innovation available to them. Figure 6.4 displays the relative importance of nine different sources based upon the number of respondents citing a source as being highly used. The bars are ranked according to the proportion of SMEs reporting public funding, such that in Denmark public funding is least reported while in Italy public funding is most widespread. Judging from the figure, the differences between countries do not seem to be that large. The most important sources for innovation are within the enterprise, from suppliers, customers and in some counties fairs and exhibitions. The own industry and enterprise group, universities and the government are less important as source for innovation by SMEs. In particular, the size of public funding appears to be unrelated with the relative importance of innovation sources.

Figure 6.4 Sources for innovation by SMEs are similar across countries (2000)



Source: CIS3 (Eurostat); a list of country codes is provided in Annex A

Nevertheless, heterogeneity between countries is substantial according to other indicators. Figure 6.2 and Figure 6.3 reveal substantial variation in the degree of international orientation of SMEs across countries. Only 19% of the Spanish innovative SMEs cooperate with foreign firms compared with almost 37% of the Belgian SMEs – not to mention the 2% of Italian SMEs.[30] A similar variation is present when looking at the share of exports in turnover (Figure 6.3).

[30] Of course, part of this variation can be explained by differences in the size of economies as firms in a large country are more likely to find a domestic partner than firms in a small country even if both have the same bias against foreign firms.

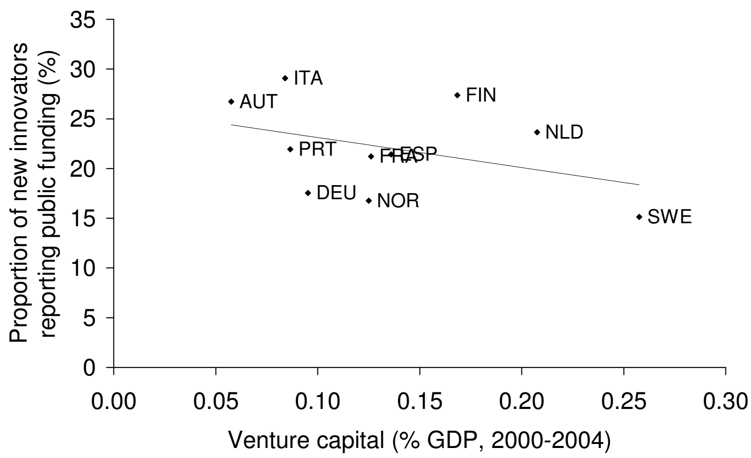
Heterogeneity in capital markets for start-up companies

Starting an innovative new firm brings along a great amount of uncertainty. Besides the risks faced by any start-up, a new innovating firm also is confronted with uncertainty about the demand for its products and the reliability and efficiency of its production process. When searching for investors, asymmetric information is therefore a greater problem for this category of firms than it is for SMEs in general. Venture capitalists have responded to this imperfection in the capital market by devoting greater resources to understanding and monitoring than other investors tend to do. In addition, governments have come up with various policies to support innovative start-ups. The importance of these two sources of finance for innovators varies in Europe.

The figure below plots the proportion of innovative start-ups who reported the use of public funds against the percentage of venture capital in GDP. The figure shows that between a third (Italy) and a sixth (Sweden) of the innovative start-ups used public funds. The difference between countries regarding the supply of venture capital is even larger: Sweden has five times as much venture capital as Austria – relative to GDP. The figure also vaguely suggests that countries in which entrepreneurs have greater access to venture capital are less likely to use public funding. This could reflect the efforts of governments to alleviate failure of capital markets, or it could point at public funding crowding out private venture capital.

These findings are consistent with a study by Wallsten (2000) on the Small Business Innovation Research (SBIR) in the USA. Wallsten finds that SBIR funding crowds out private R&D funding 'dollar for dollar'. Other authors are more arrive at more optimistic conclusions on SBIR. Lerner (1999), for example, shows that companies winning a SBIR grant tend to grow faster and attract more private venture capital than other companies, presumably because an SBIR grant is seen as a certification of quality. SBIR was also favourably judged in special issue of *Small Business Economics*, 20(2), dedicated to policies promoting innovation by SMEs in the USA and UK (Siegel et al. (2003)).

Public funding or private venture capital?



Source: CIS3, Eurostat; a list of country codes is provided in Annex A

6.4 Subsidiarity in SME and venture capital policy

There is a large variety of innovation policies targeted at SMEs. We do not deal with all these policies in particular because many of them are country specific. In stead, we have focussed on the question of subsidiarity regarding the public funding of innovative SMEs. Based on CIS3 survey results we have concluded that economies of scale are unlikely to be present in public funding of innovative SMEs. In addition, we have not found any evidence indicating the existence of policy externalities due to knowledge spillovers or foreign buyer surpluses. Although these externalities could play a role for the larger middle-sized, export-oriented firms, the evidence did not show up for the average SME. Heterogeneity in innovation sources is rather limited for European SMEs, but the degree of external orientation differs substantially from one country to another. We conclude that there is no role of Europe in coordinating innovation policies from the subsidiarity principle, however European coordination can enhance innovation by SMEs by reducing or unifying regulation and by facilitating the development of a common financial market, such that doing business abroad becomes cheaper and the supply of venture capital increases.

Successful innovation policy in the Netherlands

Cornet et al. (2006a) have identified several types of innovation policies which are potentially successful in the Netherlands. The first of them is aimed at small- and medium sized enterprises, namely the expansion of the provisions for starting innovating companies within the so-called Law Promoting Research and Development (in Dutch: Wet Bevordering Speur- en Ontwikkelingswerk, WBSO). These provisions allow innovative SMEs a deduction in wage taxes and premiums for R&D employees. In current chapter we conclude that there are no economies of scale in public funding of innovative SMEs. In addition we do not find any evidence indicating the existence of policy externalities due to knowledge spillovers or foreign buyer surpluses. There are therefore no reasons to lift the WBSO to the European scale. On the other hand, the concept of WBSO is applied in many countries (see surveys by Hall and Van Reenen (2000) and Cornet (2001)) – whether or not these subsidies should be intensified in other Member States falls outside the scope of Cornet et al. (2006a) and the current paper.

A second potentially successful policy is expansion of public support for funds that supply small amounts of venture capital loans. Two important components of such a policy are that private investors decide whether a company receives a loan and that these private investors share in the risk (Boot and Schmeits (2004)). As with the first policy, the national level seems appropriate for this kind of policy. Again, the concept of public-private cooperation in the provision of venture capital loans is not specific for the Dutch economy and can likely be successfully applied by other Member States.

7 Intellectual property rights and standards

Intellectual property rights (IPRs) not only provide firms with an incentive to innovate, but they also play an important role in the diffusion of knowledge and the development of standards. In this section, we first discuss subsidiarity issues pertaining to patent systems. Second, we describe the role of Standard Setting Organisations (SSOs) in the EU. We conclude with an assessment of the roles played by IPRs and standardisation in Europe's competition policy.

7.1 Patents

When it comes to technological innovation, intellectual property rights are usually awarded through patent systems.[31] A patent system can contribute to innovation in two ways. First, it increases the rewards to research by granting a temporary exclusive right to use the invention. Second, it stimulates the diffusion of knowledge as patents contain a complete and publicly accessible description of an invention. Not only does a patent system reduce duplicate research efforts in this way, it also provides inspiration for new inventions.

Both of these functions can be performed better if the scale of the patent system increases. Scale matters for R&D-incentives as a patent enjoying protection in all Member States of the EU is worth more than a patent valid in only one Member State. The diffusion of technology is also stimulated by the size of the jurisdiction of a patent system. A patent system spanning several countries systematically cross-references between patents granted in different countries, whereas this does not apply to patent systems restricted to single countries.[32] From an administrative point of view a larger scale also might have drawbacks as each patent application has to be compared with a larger number of granted patents. In practise, of course, an increase in scale will most likely lead to a more narrow and specialised search among earlier patents, thus keeping administrative cost within bounds.

Despite the obvious advantages of scale, the European Union still does not have a single patenting system, a system usually referred to as the "Community Patent" (see box *Applying for a patent in Europe*). There are probably four major reasons why such a Community Patent has not been established to date. First, a Community Patent will expand the average geographical coverage of a patent, thereby promoting the diffusion of knowledge via patent citations while simultaneously discouraging outright imitation of foreign inventions. Both consequences can trigger protectionist behaviour by national governments. A country with a strong knowledge base might fear an increase in knowledge spillovers abroad, while a country in which foreign inventions are being imitated on a large scale is not eager to see improvements in the IPRs of

[31] For software, copyright protection is also relevant.

[32] Officially, European patent clerks have search all patent databases in the world in order to establish newness. In practice, this is a time-consuming task – in particular because patents have to be translated.

foreign companies. Both elements give rise to a policy externality. If a country makes it easier for foreign firms to patent their inventions, for example by reducing translation requirements, this has a positive effect on the competitiveness of foreign firms vis-à-vis domestic firms. As a result individual governments will not open up their patent systems. A Community Patent internalises most of this policy externality as all Member States simultaneously reduce their barriers to foreign firms. A problem arises when the net benefit of cooperation is negative for some countries. In that case, agreement over the establishment of a Community Patent can be frustrated by a minority of Member States.

Second, there is the problem of language. The cost of translating a patent are substantial – especially when (a part of) each patent should be translated in all languages of the European Union. Only allowing patent applications in English, German or French reduces translation cost, but at the same time would introduce barriers for countries in which one of these languages is not widely spoken or understood.

Third, the Community Patent seems to be affected by a conflict of interest between SMEs and large companies. SMEs are in favour of a Community Patent if it would reduce the cost of filing and litigation. In particular, SMEs tend to be in favour of an English-only system.[33] Larger companies tend oppose the formation of a European Patent Court because they are concerned that such a new court will have insufficient experience in handling litigation procedures (European Commission (2006c)).[34] These positions confirm the view that large companies benefit from maintaining the status quo, which, coincidentally, imposes barriers to multi-country patenting – especially for SMEs.

Fourth a Community Patent is not in the interest of some of the patent offices and, especially, patent courts of individual Member States, because of a likely loss in employment. As cooperation of national offices is important for the establishment of a Community Patent, this hurdle is a difficult one to overcome.

In the last thirty years, various attempts to establish a Community Patent have been undertaken – all unsuccessful. The most recent attempt of establishing a Community Patent was titled the Community Patent Regulation (CPR). The CPR should have provided a single patent system for the EU with one court holding exclusive jurisdiction to invalidate patents. After an initial political agreement, the CPR was finally rejected in March 2004 because of failure to agree on the time delays for translation of the patent. The former Commissioner for the Common Market Frits Bolkestein commented on this rejection as follows:

[33] Italian and Portuguese SMEs are in favour of a multilingual system, instead.

[34] The position of large companies may vary across countries.

" I can only hope that one day the vested, protectionist interests that stand in the way of agreement on this vital measure will be sidelined by the over-riding importance and interests of European manufacturing industry and Europe's competitiveness. That day has not yet come." (European Commission (2004a))

From the viewpoint of subsidiarity, the Community Patent would be desirable because scale economies due to both a better protection of IPRs and wider diffusion of knowledge. A Community Patent internalises the incentive of national governments to keep their patent systems relatively unattractive to foreign firms. Heterogeneity in languages provides a powerful political argument against the Community Patent – although this argument apparently is not supported by SMEs in most Member States. A more likely explanation for the absence of a Community Patent is protectionism by Member States.

Applying for a patent in Europe

When applying for a patent in Europe the applicant can follow three routes. First, the applicant can apply at the national patent offices of the countries for which protection of an invention is desired. Second, he or she can apply for a so-called "European Patent" at the European Patent Office (EPO). When the application is made, the applicant must state in advance for which European countries the patent should apply. Protection can be requested only for the 28 countries that have signed the European Patent Convention (EPC). Once the patent has been granted by the EPO, the applicant's invention is protected in the chosen countries exactly as if patents had been granted by the national patent offices of those countries. A European Patent has to be submitted in English, German or French. For the patent to be enforceable it must have been translated in an official language of the contracting state for which protection is being sought.

A third route to a patent is through the Patent Cooperation Treaty (PCT) (Khan and Dernis (2005, Annex A)). The PCT currently has 131 contracting states. A PCT application has two phases. In the first phase a "receiving" patent office – which is the EPO for several European countries amongst which The Netherlands – conducts an international search and (optionally) performs a preliminary evaluation of the patent application. In the second phase, the application together with the findings of the receiving office is transferred to the national patent offices, which then decide whether or not to grant a patent for their jurisdiction.

The drawback of the European Patent is that once a patent is granted, it effectively becomes a collection of national patents. As a result any litigation can only take place at the national level, raising the cost of a defence against patent infringement spanning multiple countries. In addition, the protection of a European Patent varies according to national patent laws. Since the 1970s there have been attempts to establish a patent system that is truly European, commonly referred to as the "Community Patent" (European Commission (2006b), Wikipedia (2006)). The 1975 Convention for the European Patent for the Common Market (CPC) should have led to a Community Patent but was not ratified by all of the nine signing countries. Several unsuccessful attempts to revive the Community Patent have followed, the most recent being the Community Patent Regulation (CPR).

7.2 Standards

Three types of market failures related to standardisation have been discussed in Section 2.1.4. Markets may tolerate to a lock-in into inferior standards set by dominant firms, a lack of standardisation or excessive standardisation. Governments generally leave the development of standards to SSOs, which are better suited to prevent inferior standards and to promote standardisation.

Reference to SSO standards in laws and regulation is common, but usually is confined to areas related to safety, health and environment. In these areas, standardisation has predominantly been elevated to the European level with the adoption of the New Approach to product regulation, which started in 1987 (European Commission (2000)). As a consequence, non-tariff barriers to trade within the EU have been reduced significantly. Under the New Approach, the European Commission can instruct one of the three European Standards Organisations (ESOs, see box below) to develop standards that are consistent with a regulation.[35] Most of the activities of ESOs are performed directly for private parties. The scale advantages of standardisation are widely recognised by the ESOs and they actively work together with international standards bodies like the IEEE, ITU and ISO.[36]

Standards commissioned by the EC are not mandatory, but once a firm complies with these standards it automatically complies with European regulation. Firms wishing not to adhere to applicable standards need to prove that they are complying with European regulation before they are allowed to sell their products. Needless to say, this can be much more costly than adapting to standards recognised by the EC. The involvement of the EC or national governments in standard-setting outside the domain of safety, health or environment is rather limited.

Not all standardisation takes place at the European level. National SSOs like the "Nederlands Normalisatie-instituut" (NEN) are still actively developing standards. As the value of a standard crucially depends on the scale on which it is used, a European standard generally is to be preferred over a national standard. Blum (2005), for example, argues that all national standards bodies should merge into the ESOs for this reason.

This kind of scale economy is due to network effects stemming from interoperability rather than the presence of fixed cost or the internalisation of policy externalities. Although the fixed cost of developing a standard can be substantial, there would be no reason for making these costs if network effects are absent as in that case the standard would be worthless. The internalisation of policy externalities also is not likely to be the primary source of scale

[35] Besides the EU, also members of EFTA delegate the development of standards to these institutes.

[36] The abbreviations stand for: Institute of Electrical and Electronics Engineers (IEEE), International Telecommunications Union (ITU), and International Organisation for Standardisation (ISO).

economies in standardisation policy. In principle, a country could free-ride on standards developed in other countries. Considering that SSOs mostly work on a commercial basis, such a policy externality is unlikely to cause major problems.

An argument against ESOs would be that they prevent competition between standards. This argument is not very plausible as competition between standards on a European or global market is very well possible[37] and is better than 'competition' between national standards, as in the latter case country size will be decisive in stead of the quality of the standard. A more plausible argument in favour of the continued existence of national SSOs alongside the ESOs is that national organisations can better respond to the specific needs of national governments and firms. In addition the ESOs provide a platform for coordination between national standards bodies.

The ESOs are not subject to the political controversy that has surrounded the Community Patent. Having reached a high degree of institutional integration, the current priorities of the EC are "more extensive use of European standardisation in European policies and legislation", raising the efficiency of the ESOs and promoting the involvement of SMEs in European standards (European Commission (2006a)).

The three European Standards Organisations

The three ESOs are the European Telecommunications Standards Institute (ETSI), the European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (CENELEC). The activities of ETSI are confined to telecommunications. ETSI is responsible for standards like GSM, ADSL and DECT (portable fixed-line phones). CENELEC is concerned with the standardisation of electro technical equipment. CENELEC has contributed standards for electromagnetic compatibility, the accuracy of medical devices and digital television. CEN develops standards for areas not covered by ETSI or CENELEC, as diverse ranging from building materials to condoms. The ESOs have developed rather independently from the EU and are already several decades old: CEN was established in 1961, CENELEC in 1973 and ETSI in 1988.

7.3 Competition policy

Competition in innovative industries is far more complex than in less innovative, more traditional, industries. One reason for this complexity is that an innovation often requires the intellectual property of several firms. This implies that firms have to cooperate in order to be innovative. Such cooperation can take several forms: firms may cross-license patents, they might contribute them to a patent pool[38] or they can make them available for use in standards against Reasonable and Non Discriminatory Licensing (RAND) terms. However, cooperation between firms can also reduce competition and thus may be harmful as it raises prices (Encaoua

[37] The IEEE, for example, supports various competing standards on wireless communication protocols and DVDs.

[38] A patent pool is a collection of (complementary) patents that can be licensed collectively.

and Hollander (2002)). Competition authorities face the difficult task of deciding whether the benefits of cooperation (new or better products) outweigh the cost (a higher price).

The complementarity of intellectual property belonging to different firms also can lead to anti-competitive behaviour if one firm refuses to license a patent or disclose information to another firm. Competition authorities here face the trade-off as well. If licensing against RAND terms is made obligatory then this reduces the reward for innovation for the licensing firm. If a refusal to license is tolerated then innovation by the would-be licensee is hampered. The same dilemma applies to the disclosure of business secrets like the source code of software programmes.

Anti-competitive behaviour in innovative industries is not always easy to identify by competition authorities. In order to create a ‘safe harbour’ for firms desiring to cooperate on innovation, the EC has granted a ‘block-exemption’ for the transfer of technology between two companies. This means that licensing agreements for patents, software and other IPRs are automatically considered not to be anti-competitive – provided that certain conditions have been met (European Commission (2004b)). The block-exemption for technology transfer does not apply to the development of standards because they usually involve more than two parties. For this reason, ETSI actively seeks to prevent anti-competitive behaviour of its members through education and screening of agreements (ETSI (2001)).

Major R&D efforts by private companies are rarely a domestic affair. Often several multinational companies cooperate in order to develop a new product or create a global technical standard. National authorities – with the exception of the US Federal Trade Commission – have very limited powers when multinational companies engage in anti-competitive innovative actions. A joint European competition policy is therefore necessary in order to prevent anti-competitive outcomes of R&D collaboration on a European scale. Fortunately, coordination of competition policy in the EU is in a rather advanced state. National regulatory authorities work in accordance with EC regulation for local cases, they cooperate on multinational cases and exchange information in the European Competition Network (ECN) and the most severe and complex cases – e.g. the case concerning the Microsoft Windows operating system – are being handled by the EC’s Directorate General for Competition.

7.4 Subsidiarity in IPR and standardisation policy

The benefits of European coordination are clear when it comes to the protection of intellectual property rights (IPRs), the promotion of standardisation and the prevention of anti-competitive behaviour in innovative activities. Nevertheless, experiences are mixed when it comes to the degree of European coordination that has been achieved so far. European coordination is currently insufficient when it comes to the protection of IPRs. The application procedure at the European Patent Office (EPO) is fully centralised, but once a patent has been granted it falls under national legislation. As a consequence, the patent should be translated into an official language for each country the patent is to be registered with. In addition, litigation procedures are country specific. Both elements make acquiring and defending patents an expensive affair – especially for SMEs. Political arguments against the establishment of a Community Patent are based on the heterogeneity of languages in the EU. However, a policy externality in the form of protectionism seems to be the underlying factor here.

European coordination is at a more advanced stage for standardisation and competition policy than it is for IPR policy. Both standardisation and competition policy take place at three levels: national, multinational and European. The European Standards Organisations develop voluntary European standards in coordination with international standards organisations. In addition they provide a platform for multilateral cooperation between national standards bodies. Scale economies in standardisation stem from network effects rather than the internalisation of policy externalities.

A similar institutional structure can be found for competition policy. The European Commission deals with anti-competitive behaviour occurring on a (supra-) European scale, while national competition authorities coordinate for multinational cases via the European Competition Network. Maintaining these three levels of policy has the advantage being able to exploit scale economies where possible while preserving the flexibility needed to cope with national idiosyncrasies.

8 European Framework Programmes

8.1 Seventh Framework Programme (FP7)

8.1.1 Description

The Seventh Framework Programme[39] (FP7) is an initiative of DG Research under which various subsidies are granted for both public and private research. The proposed budget of FP7 currently is 53.3 billion euros for the period 2007-2013. This amounts to an average yearly budget of 7.6 billion euros, which is substantial when compared to the 65 billion euros spent on public research by the Member States of the EU in 2003. FP7 consists of four programmes:

- Cooperation (32.4 billion)
- Ideas (7.5 billion)
- People (4.7 billion)
- Capacities (4.2 billion)

Besides these four programmes and the budget of EURATOM, FP7 also has a budget for the Joint Research Centre (JRC) amounting to 1.8 billion euros and a budget for research on nuclear energy (EURATOM) of 2.8 billion euros.

Cooperation. The programme Cooperation receives the bulk of the FP7 budget. The objective of this programme is "supporting the whole range of research actions carried out in trans-national cooperation" (European Commission (2006d, p. 175)). The programme covers collaborative research in ten thematic areas.[40] All kinds of transnational consortia – public, private and public-private – can apply for subsidies for research activities. Support for transnational cooperation will be implemented through Collaborative Research, Joint Technology Initiatives, Coordination of non-community (national and inter-governmental) Research Programmes and international cooperation.

Collaborative Research provides funding for transnational collaboration and has the bulk of the programme's budget. Proposals for projects under the sub-programme Collaborative Research must be made by at least three legal entities, no two of which are established in the same Member State. In this manner an incentive is offered for transnational cooperation. In the previous framework programme (FP6), the participation of the private sector was rather limited (SER (2004)). The European Technology Platforms (ETPs) should give the private sector more influence on the priorities of FP7. These ETPs consist of business-leaders who are going to

[39] FP7 actually consists of two framework programmes: the "Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities" and the "Seventh Framework Programme of the European Atomic Energy Community (EURATOM) for Nuclear Research and Training Activities".

[40] The exact number and description of the themes is still being debated at the publication time of this report.

formulate Strategic Research Agenda's that should give a direction to the allocation of funds. If an ETP is deemed to be of strategic importance for the EU, it can be turned into a Joint Technology Initiative. Joint Technology Initiatives provide funding for long-term public-private research projects based on the Strategic Research Agenda's. Coordination of National Research Programmes offers possibilities for multilateral cooperation and joint implementation of public policies.

Ideas. The programme Ideas establishes a European Research Council (ERC). The ERC should fund projects proposed by researchers, similar to the National Science Foundation of the US (and the Dutch NWO). Formally, the objective of this programme is "supporting 'investigator-driven' research carried out across all fields by individual national or transnational teams in competition at the European level". Only one legal entity is required for funding.

People. The programme People is meant to financially support individual researchers in the EU. The Marie Curie Fellowships are an example of what is covered by the programme. The objectives are to improve both the quantity and quality of researchers and to make researchers more mobile in the EU.

Capacities. The programme Capacities comprises a list of things that are to be supported: research infrastructures, research potential of regions, research for SMEs, Science in Society, "support to the coherent development of policies" and "horizontal activities of international cooperation". The emphasis seems to lie on support for research infrastructures and SMEs.

8.1.2 The EC's perspective on the subsidiarity of FP7

Legally, the Treaty of Amsterdam recognises a role for an EU policy on research and technological development (RTD) in articles 163 to 173. It further defines Framework Programme's as the primary instrument for such a policy. However, official documents by the EC offer few answers to the question why FP7 would be preferable to separate national innovation policies. An exception is the commission staff working paper provided as an annex to the FP7 proposal (European Commission (2005b, Annex p. 21)). Specifically, the document cites three types of arguments for EU intervention.

- Pooling and leveraging of resources
- Fostering human capacity and excellence in S&T through training, mobility, career development and competition at European level
- Better integration of European R&D policies

Pooling and leveraging of resources. This type argument refers to scale economies in research projects as a reason for EU involvement. A distinction is made between achieving "critical mass", leveraging private investment and enabling "big science". It not made very clear what a critical mass should entail, but it can be achieved by multinational and interdisciplinary collaboration. Probably, what is hinted at here is that EU-funded research projects contribute to integration of European R&D, which results in scale economies through the formation of a larger knowledge base. This type of argument has been discussed in Section 2.2.2. EU-support for private R&D has the advantage that it allows cooperation of firms from different countries. National governments will not support a group of firms collaborating on research if one of those firms is foreign as part of the benefits will leak abroad. EU-coordination can resolve this prisoner's dilemma for collaboration between European firms as the benefits of EU support remain within the EU, see Section 3.2 for a detailed discussion of issues like this one. The big science argument refers to research projects with high fixed cost. Some research projects are too expensive and complex to be managed by a single country. At the European scale, however, such large projects can be more feasible (see Section 2.1.6).

Fostering human capacity and excellence. Four arguments are put forward under this heading: facilitating mobility of researchers, making Europe more attractive for researchers, promoting knowledge diffusion and enabling pan-European competition for funding of public research. Mobility of researchers clearly is an aspect of an integrated European research area and as such is within the domain of EU-policy. Whether European grants are an effective instrument for making Europe a more attractive place for researchers, is debatable as these grants do not change the functioning of universities and research institutes. The last two arguments, that FP7 promotes knowledge diffusion and competition among researchers, also refer to the economies of scale in research. A better diffusion of knowledge makes it easier for researchers to prevent duplication and provides incentives to researchers to specialise themselves. This argument has been discussed in Sections 2.1.6 and 2.2.2.

Better integration of European R&D policies. Two points are made here. First, pan-European challenges to public policy can better addressed by a single European policy. This argument refers both to free-rider problems caused by policy externalities and to scale economies in public administration. Cooperating on R&D policies can prevent that some countries are 'free-riding' on R&D expenditures of other countries. Centralisation of R&D policies can improve the selection procedures for R&D projects, reducing cost and preventing duplication. A more detailed discussion can be found in Chapter 3. A second argument is that coordination of national policies reduces overlap and isolation of national public research and promotes diffusion of research results. This argument implicitly refers to scale economies in research, as was the case for "Fostering human capacity and excellence". Scale economies in research have been covered more extensively in Sections 2.1.6 and 2.2.2.

Summarising, the working document emphasises that FP7 should promote economies of scale in both public and private research. Less often mentioned as a rationale for EU-coordination are policy externalities and scale economies in public administration. No opinion is given on what aspects of innovation policy should remain a national responsibility.

8.1.3 The subsidiarity principle applied to FP7

The largest part of FP7 can be classified as centralised policy. Only one instrument of the programme Cooperation is concerned with multilateral cooperation on innovation policies. FP7 is confined to allocating funds to public and private research. As such, it covers only some of the aspects of innovation policy. The following of the policy instruments treated in Chapters 4 through 7 are being used in FP7: public investment in R&D, public funding of private R&D (including public-private collaboration) and SMEs and venture capital. The theoretical arguments for policy centralisation of public research are economies of scale in research and in public administration. In FP7 these arguments are reflected in the objectives of the majority of its programmes. The programmes Cooperation and People should foster the diffusion of knowledge within Europe, while the programme Ideas can benefit from economies of scale in public administration by avoiding duplication and by a more efficient allocation of funds.

The explorative empirical analysis of Chapter 4 has shown that the proportion of public R&D in total government expenditure depends positively on GDP. The economies of scale are probably mainly caused by the internalisation of policy externalities. Countries in which a high proportion of domestic patents is owned by foreign companies spend less on public R&D than countries in which this kind of 'leakage' is limited. Together, the theoretical and empirical analysis provide sufficient ground for European coordination of public research.

The second instrument available in FP7 is public funding of private R&D. Our empirical analysis has shown that economies of scale are likely to occur, but that these scale effects are probably not due to the internalisation of policy externalities. The main purpose of this instrument is to promote economic integration in innovative sectors, such that economies of scale in research can be exploited.

The programme Capacities is aimed at research infrastructures, SMEs and backward regions. Neither the theoretical nor the empirical analysis provide any support for European coordination of this programme. No scale economies are present and there also are no policy externalities involved. Therefore, support specifically targeted at SMEs does not seem justified from the perspective of subsidiarity – with the exception of support that is intended to reduce the barriers faced by SMEs when trying to participate in FP7.

Summarising, the Seventh Framework Programme is largely consistent with the principle of subsidiarity for most of its programmes. The programme Capacities forms the only exception: the activities of this programme predominantly belong to the domain of national policy.

Universities: higher education and innovation

A large share of the FP budget is allocated to research proposals by universities. For universities framework programmes are important to fund research. The requested international cooperation by FP increases the international orientation of universities. Besides the job market for universities is becoming more and more international, and international student mobility increases. From these developments one could mistakenly conclude that universities should be completely financed by Europe instead of national governments. Ederveen and Thissen (2006) address the question whether there are arguments to shift higher education policies from the national to the European level. Using subsidiarity as guiding principle in their analysis (as is done in this document) they find little support for European coordination of higher education. First, they find no support for economies of scale, i.e. larger countries do not necessarily provide higher quality education; nor do larger schools. Second, empirical evidence for human capital externalities through student mobility is scarce. However, there is evidence that student mobility is a precursor for labour migration. A uniform structure of higher education in the EU, and making educational programs more transparent, may therefore be defended from this perspective. Quality does matter for students, and student mobility is increasing. This may be beneficial to labour mobility.

8.2 Competitiveness and Innovation Framework Programme (CIP)[41]

8.2.1 Description

The Competitiveness and Innovation framework Programme (CIP) is an initiative of DG Enterprise and Industry. The proposed budget is 3.6 billion euros for the period 2007-2013 (or 0.5 billion euros annually), which is less then 10% of the budget for FP7. The CIP consists of three specific programs:

- The Entrepreneurship and Innovation programme (3/5 of the budget)
- The ICT policy support programme (1/5 of the budget)
- The Intelligent Energy – Europe Programme (1/5 of the budget)

The Entrepreneurship and Innovation Programme will bring together activities on entrepreneurship, small and medium-sized enterprises, industrial competitiveness and innovation. It encompasses the promotion of public-private innovation partnerships for SMEs, the provision of community financial instruments to overcome the poor access to equity, venture capital and loans for SMEs and the exchange of good practice between national and regional authorities.

The ICT policy support programme will stimulate the wider uptake of ICT by citizens, businesses and governments and aim at intensifying the public investment in ICT. The role of the EC is to enable the development of common approaches and coordinated actions, the

[41] Based on European Commission, 2005, Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a Competitiveness and Innovation Framework Programme (2007-2013), Communication 121 final.

sharing of good practices and the deployment of interoperable solutions across the Union – all in support of the private sector and the Member States, which are the key actors in the deployment and best use of ICT.

The objective of the Intelligent Energy – Europe Programme is to support sustainable development as it relates to energy and to contribute to the achievement of the general goals of environmental protection, security of supply and competitiveness. It is a non-technological programme in the field of energy focusing on the removal of non-technical barriers, the creation of market opportunities and raising awareness.

8.2.2 The EC's perspective on the subsidiarity of CIP

The EC stresses the potential for Member States to learn from each other in their innovation policies regarding SMEs. The EC recognises the fragmentation along national and regional lines, which hinder Member States in drawing on the creative potential in other EU countries. The EC also points at the deficient provision of national policies regarding failures in financial markets and intents to stimulate the diffusion of good practice across Member States.

The second motivation to involve in innovation policies for SMEs is to foster business cooperation throughout the EU. The access for firms to innovation policy will be easier if all Member States adopt a common support structure.

In both cases, the EC recognises the key role for national and even regional policy. The aim of the CIP is mainly to support these national innovation policies and allow Member States to learn from each other.

8.2.3 The subsidiarity principle applied to CIP

The CIP is aimed at SMEs, some of them might operate internationally (via FDI or trade), but many of them are local firms operating for the local market. Rightly, the EC recognises the prime responsibility of Member States in innovation policy regarding SMEs.

The diversity in SME policy between Member States justifies the attempt to learn from each other. Given the large diversity in national innovation policies towards SMEs, the potential to learn is large. Learning is, however, hampered by the fact that not only policy diverges, but also the SMEs themselves are quite heterogeneous. This limits the possibility for one Member State to successfully apply the innovation policy of other countries.

The arguments developed in Chapter 6 on SMEs, entrepreneurship and venture capital apply to the Entrepreneurship and Innovation Programme and the ICT programme. Neither scale economies nor external effects seem to be important in both programmes and warrant EU intervention. European involvement is justified only insofar CIP meets the goals of reducing regulations for innovative SMEs and of promoting policy learning between Member States.

A clear role for the EU is reserved for the Intelligent Energy – Europe Programme, which clearly deals with the European, not to say worldwide problem of greenhouse gas emissions.

Stimulating SMEs to develop and adopt energy-efficient technologies contributes to this global problem.

Annex A: Country codes

List of country codes (ISO Alpha 3 codification)

AUT	Austria	HVR	Croatia
AUS	Australia	IRL	Ireland
BEL	Belgium	ISL	Iceland
BGR	Bulgaria	ITA	Italy
CAN	Canada	JPN	Japan
CHE	Switzerland	LIE	Liechtenstein
CYP	Cyprus	LTU	Lithuania
CZE	Czech Republic	LUX	Luxembourg
DEU	Germany	LVA	Latvia
DNK	Denmark	MLT	Malta
ESP	Spain	NLD	Netherlands
EST	Estonia	NOR	Norway
EU	European Union	POL	Poland
EU15	EU (15 countries)	PRT	Portugal
EU25	EU (25 countries)	ROU	Romania
FIN	Finland	SVK	Slovakia
FRA	France	SVN	Slovenia
GBR	United Kingdom	SWE	Sweden
GRC	Greece	TUR	Turkey
HUN	Hungary	USA	United States

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