Expert Group on Impacts of R&D Tax Incentives

Design and Evaluation of Tax Incentives for Business Research and Development

Good practice and future developments

Final Report

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The views expressed in this report are the sole responsibility of the members of this expert group and do not necessarily reflect the views of the European Commission.

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Executive summary

Since the early 2000s, the European Commission has paid an increasing attention to the role of R&D tax incentives in driving research and innovation in Europe. Two recent initiatives are the 2005 CREST OMC Working Group on Evaluation and Design of R&D Tax Incentives [which led to the Communication "Towards a more effective use of tax incentives in favour of R&D", COM(2006)728] and the 2008 Expert Group on R&D Tax Incentives Evaluation.

In 2009, the Commission established the current expert group on Impacts of R&D Tax Incentives. The group was given the task of assessing and updating the advice given by the two previous expert groups, taking into account recent developments and experiences. In addition, the group was requested to study the effects of the tax incentives on R&D collaboration between businesses and research organizations, and on the location of R&D investments.

The expert group notes that conditions have changed somewhat since 2006, due to more generous R&D tax incentives in some countries, a movement towards simpler volume-based designs, and more liberal EU rules related to state aid for business research and development. Moreover, the work of the expert group takes into account two other important developments:

- The European Union has not come significantly closer to the overall goal of investing 3 per cent of Gross Domestic Product in R&D
- Global economic downturn may slow down the pace of R&D investment by the private sector.

The expert group believes that developments since 2006 have *not* brought to light new facts, experiences or insights that imply that there is a need to revise the work on design of tax incentives done by the CREST working group and the 2008 expert group. Recent reforms of tax incentives in several countries are generally in line with the advice given by the previous groups (see sections 3.1 and 4.1 below). The advice stays solid despite the fact that Europe is missing its 3 per cent goal by 2010 and the European economy has experienced a serious economic downturn. However, there are areas where the knowledge base for the sound design and evaluation of tax incentives can be improved, and the expert group has some additional suggestions to offer, supplementing previous advice, all enumerated below.

Designing R&D tax incentives

Generosity

Small tax incentives might not have much impact on business R&D decisions. Overly generous ones would stimulate projects that from a societal point of view may not deserve to be carried out, and might cost more to the public purse than the increase in R&D that is induced by the incentive. The expert group believes that the knowledge base for policy decision related to how generous tax incentives should be under different national conditions needs to be strengthened.

The expert group therefore suggests that additional research is carried out on the optimal design for R&D tax incentives.

The expert group has noted that a number of countries have especially generous tax incentives for industry-science collaboration. It is not evident whether such schemes address a market failure and do it in targeted manner. The expert group thus suggests that this issue is studied further.

Stability

The uptake of a tax incentive will in part depend on whether the business community believes that the scheme will be stable. The expert group therefore suggests that if a tax incentive needs to be modified, ongoing R&D projects should as far as possible be sheltered against new rules. In particular, changes that make a tax incentive less favourable may have a harmful impact on the already started projects. In addition, it is proposed that any amendment to the tax incentive be developed in consultation and cooperation with the private sector.

New tax incentives

Preferential tax treatment of young innovative companies has been introduced in some countries. Some countries also have tax incentives for angel investors in R&D companies (i.e., individuals who possess significant own capital and private investment experience). The expert group proposes that such schemes are studied in order to ascertain how they function and how they fit within the general schemes for R&D

Tax incentives and the service industries

The service industries play an important role in most countries' economy. Usually tax incentives have been designed with the manufacturing industry in mind. The expert group therefore suggests that a study be initiated to find out how well the R&D tax incentives in place suit innovation in the service industries. If such a study is initiated, it could also cover innovations in the entertainment and culture industries.

Administration and compliance

Although tax incentives are usually an efficient way of ensuring government support for R&D, they also entail an administrative burden. They typically involve the administration (e.g., delivery and oversight) cost for government and compliance cost for business. These costs may affect how attractive and generous the schemes truly are, and thereby how much more business R&D they will lead to. In addition to the direct compliance costs to business, such as filling in the time sheets and government forms, there might be hidden ones related to opportunities lost due to time diverted from R&D activities. The administration and compliance costs of various schemes need to be given more focused attention in design and evaluation of the tax incentive. The expert group proposes that a benchmarking study is initiated, comparing R&D tax incentive programs internationally and identifying good administration and compliance practices.

Evaluating R&D tax incentives

While the expert group generally agrees with the advice on evaluation given by the 2005 CREST Working Group and the 2008 Expert Group, it has identified areas and actions where the existing guidelines can be supplemented and new initiatives could be taken.

Appropriate and cost-effective scope of evaluation

Evaluations should be limited to issues that are important to pursue from a policy perspective, and the most appropriate evaluation methods should be used to answer the questions that are to be studied. A major cost of comprehensive evaluations is related to data gathering. These costs can be held down if the collection of data is integrated in the running of the scheme and if the collection of data for the national business statistics takes account of the need for long time series of information for evaluations and studies of how the innovation system functions.

Administration efficiency

As the administration and implementation of a tax incentive is important to the overall take-up of the scheme, the expert group suggests that these aspects of tax incentives are regularly scrutinized, with the goal of continuous improvement in the deployment of the schemes.

New evaluation approaches

Recently, new cost-benefit methods of evaluation based on parameters assembled from evaluation literature have been developed to assess, in a partial equilibrium context, the net economic impact of R&D tax incentives. These models could offer a time-conscious and cost-effective approach to evaluations and deserve to be studied more in detail. However, the expert group cautions that such meta-evaluations bring in a whole new set of issues including the underlying assumptions, methods used and reliability of data sources, particularly those on the magnitude of spillovers.

Evaluations into new areas of impact

The expert group observes that two areas of R&D tax incentive impact deserve further evaluations:

- Location and relocation of R&D investments: The expert group has studied the question of whether tax incentives effect the location of business R&D and whether tax competition between countries could result in a zero sum game with no total increase in R&D. The expert group has found that the evidence on this issue is still limited. The expert group thus proposes that the question of (re)location be studied further. The question, however, remains on how governments can evaluate the successfulness of their R&D tax incentive policies in affecting the location of R&D. The key ingredients of such evaluations are (1) availability and access to firm level panel data (cross-sectional and over time) and establishment data both across countries and within countries (2) the use of robust identification strategies. Both of these elements are essential for understanding the causal impact of R&D tax incentive on both the decision to invest in R&D in a particular country and the amount of that investment. The increasing availability of cross-country firm-level data might be a new source of information that studies on this issue could exploit.

- Industry-science R&D collaboration: The expert group finds that there are practically no evaluations of the effectiveness of additional tax credits for business R&D projects that are undertaken with the involvement of public science. It might be possible and desirable to launch evaluation studies of these specific R&D tax credits programs. As a starting point, conducting micro-econometric evaluations appears to be a good option for future studies. Although policy evaluations are often conducted via in-depth case studies of program participants, an initial quantitative econometric study may be a feasible first step despite the usual heavy data requirements for such studies.

Predictive tools

Evaluations rarely link specific design features to the effects of the tax incentive. For countries setting up a tax incentive or planning changes in their systems, there is therefore little precise knowledge of the effects of different elements in a tax scheme. On this basis, the expert group suggests that a study is undertaken to look into the possibility and desirability of developing predictive tools for assessing the effects of different design options. Such tools could consist of different types of simulation models. One could also envisage "laboratory experiments" where stakeholders are exposed to different design alternatives in order to study their responses to tax incentives.

Cultivation of experience

Designing and evaluating R&D tax incentives calls for specialized knowledge and experience, and such insight is strengthened by learning from experts in other countries. The expert group therefore suggests that a network for sharing experiences and examples of good practice in the design and evaluation of R&D is established. A possible approach could be to get member countries to name experts who could be part of the network, and that the participants meet at least once a year to exchange insight and experiences, and to suggest further studies or other measures that might be called for. One could even imagine joint evaluations in particular cases.

Credibility of evaluations

Evaluators should not only be independent, but also capable and experienced, and chosen through a transparent process. A credible evaluation should furthermore involve stakeholders in the entire evaluation process.

1 Introduction

1.1 Previous EU studies

Since the early 2000s, the European Commission has paid an increasing attention to the role of R&D tax incentives in driving research and innovation. In 2003, an independent expert group delivered a report, which stressed the importance of design to the effectiveness of R&D tax incentives. It also called for more formal evaluations of tax incentive schemes.[1] This was followed in 2004 by a report that mapped tax incentives and their evaluations undertaken in the European Union.[2] The report argued that there was a lack of evaluations and hence little information concerning the efficiency and effectiveness of tax incentives. The report also suggested that issues related to fiscal design should be treated more in detail in future studies.

Two recent initiatives are the 2005 Scientific and Technical Research Committee's (CREST) Open Method of Coordination (OMC) Working Group on Evaluation and Design of R&D Tax Incentives and the 2008 Expert Group on R&D Tax Incentives Evaluation.

In 2006, the CREST working group issued a report on evaluation and design of R&D tax incentives accompanied by a handbook of practical guidelines on the evaluation of tax incentives.[3] The aim of these guidelines was to encourage the spread of good practice in this area in EU member states. The group presented advice on how to go about the design and evaluation of tax incentives, reflecting the state of the art in the field and recent country experiences.

The 2008 Expert Group on R&D Tax Incentives Evaluation was established to suggest ways of improving the evaluation of R&D tax incentives in practice, and to help increase coherence and comparability among the evaluation methods used by European Union member countries. In its report the expert group suggested *inter alia* that the effect of tax incentives on R&D collaboration between businesses and research institutions should be studied, as also the possible effect of tax incentives on the location of R&D. Furthermore the expert group underlined the need to continually improve the practice of evaluations, their coherence and comparability by actively encouraging international collaboration in this area.

[1] European Commission, *Raising EU R&D Intensity: Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development : Risk Capital Measures*, Brussels 2003, http://ec.europa.eu/invest-in-research/pdf/download_en/report_riskcapital.pdf

[2] Expert Group on Fiscal Measures for Research, Report submitted to CREST in the context of the Open Method of Co-ordination, The Hague, June 15, 2004 , http://ec.europa.eu/invest-in-research/pdf/download_en/omc_and_fiscal_measures_for_research.pdf

[3] *Evaluation and design of R&D tax incentives*, Report of the CREST Expert Group on Fiscal Measures, European Commission, Brussels, March 2006. Also see, *Handbook on the Evaluation of R&D tax incentives*, 17 March 2006

1.2 About the Expert Group on Impacts of R&D Tax Incentives

The Commission established the present expert group in 2009. An overall aim was to take stock of previous reports and study two issues that had not been given much attention previously. Thus the mandate of the expert group comprises the following tasks:

- Examine the guidelines on the evaluation and design of R&D tax incentives, produced as an annex to the 2006 CREST report, in the light of the recent work by 2008 Tax incentives Expert Group on evaluating tax incentives schemes and revise the guidelines accordingly.

- Gather, examine and analyze the evidence concerning the effect of tax incentive schemes on the nature and intensity of R&D of private companies. Such an examination should distinguish between the impact by size of company, by sector and the inducement for companies to undertake research with universities and research institutions.

- Gather, examine and analyze the evidence concerning the effect of tax incentive schemes on the location of R&D and its evolution over time. Of particular interest is the effect on R&D into or out of the EU, as well as diversions within the EU.

Members of the expert group have been:

- Dr. Chiara Criscuolo, London School of Economics, United Kingdom; and OECD

- Dr. Dirk Czarnitzki, Katholieke Universiteit, Leuven, Belgium

- Christian Hambro, Gram, Hambro & Garman, Oslo, Norway

- Jacek Warda (Chair), JPW Innovation Associates Inc., Ottawa, Canada

Members of the Expert Group were effectively supported by the team of professionals from European Commission's Directorate General for Research. Richard Cawley, Tiit Jurimae and Fabienne Mollet provided valuable assistance in the expert group's deliberations, workshop organization and report preparation.

On September 23, 2009 the expert group organized a workshop in Brussels, The group received important comments and suggestions on their discussion papers and draft report from discussants - Otto Toivanen, Helsinki Center of Economic Research, Michele Cincera, JRC-IPTS/KFG-IRI, and Arie van der Zwan, Ministry of Economic Affairs, Netherlands - and from workshop participants.

1.3 Approach

According to the mandate, the expert group has studied the possible impact of tax incentives on the location of R&D and research collaboration between the private sector and research institutions. These issues have not been dealt with in any depth in previous EU reports. The expert group's conclusions on these topics are based on a thorough review of literature.

The expert group has reviewed the advice given by the two preceding expert groups (i.e., CREST working group of 2005 and the expert group of 2008). This part of the expert group's job has been a "tabletop" exercise, in the sense that it has relied on previous advice and recommendations and on the members' insight and experience, without leaning on new scientific studies prepared for the expert group. In the course of its deliberations, the expert group has noted that some of the advice given by previous groups is based more on experience and common sense than on scientifically tested empirical evidence. This has led the expert group to suggest that some issues deserve to be studied more in depth, particularly questions related to the design of tax incentives.

It should be noted that the mandate of the expert group does not include general R&D – or tax policy issues. This implies that the mandate to a certain degree excludes a holistic approach to the questions that have been studied (e.g., tax incentives in the policy mix). The expert group, however, does not believe that this limitation has had a significant bearing on the advice that is given.

Advice related to the design and evaluation of tax incentives should evidently take into consideration the current policy situation. The expert group has therefore looked into the question of whether previous advice should be modified due to changed circumstances in recent years, notably the recent economic downturn and that the EU Lisbon goal for increasing R&D investments up to 3 % of the GDP by 2010 evidently is not going to be met.

1.4 Organisation of the report

Following introductory section 1, the report is organised into four major sections. Section 2 discusses what has changed with respect to R&D tax incentives internationally since the publication of the 2006 CREST report, including the possible implications for the design and evaluation. Accordingly, section 3 and section 4 present the expert group's new advice in the area of design and evaluation of R&D tax incentives, building on the work of CREST Working Group of 2005 and the Expert Group on R&D Tax Incentives Evaluation of 2008.

A set of annexes rounds up the report. Two discussion papers referenced in this report and a resource paper on financial constraints for industrial innovation follow immediately. The papers provide important background on issues discussed in the main report. They contain formal discussion of theoretical and empirical literature and technical information pertaining to R&D tax treatment of collaboration and location. The two discussion papers are: *The effect of R&D tax incentives on location of R&D investment* written by Chiara Criscuolo (Annex 1), and *Tax incentives for industry-science R&D collaboration* written by Dirk Czarnitzki (Annex 2). Annex

3 presents a background paper by Dirk Czarnitzki and Hanna Hottenrott: *Financing constraints for industrial innovation: What do we know?*

This is followed by two templates summarizing R&D tax incentives. Annex 4 includes a template summarizing and comparing R&D tax incentives in the European Union and other major economies. Annex 5 compares the country tax treatment of industry-science R&D collaboration and R&D investment location decisions.

Finally, Annex 6 provides an official agenda for the workshop.

2 R&D tax incentives and new economic circumstances

Over the recent years, the R&D political scene has changed in two ways. First; the European Union is lagging behind in its efforts to increase the level of R&D and has not come significantly closer to the overall goal of investing 3 per cent of Gross Domestic Product in R&D.[4] Second; a recent economic downturn may have slowed down the pace of R&D investment by the private sector.

2.1 R&D tax incentives and the Lisbon goal

Whether the Lisbon goal of 3 per cent is well founded has been a subject of considerable debate.[5] Although the 3 per cent mark will not be met by 2010, the EU has upheld the goal as a long term ambition.[6]

It falls outside the mandate of the expert group to give advice on what is an appropriate level of R&D in any given country or in the EU. However, if a country intends to increase its level of R&D, it should choose the best instruments available for achieving these objectives.

Taking into account that most countries have upheld the 3 per cent target and that the increase in R&D in most countries has been limited over the last five years, introducing tax incentives for R&D, or enhancing existing schemes, seems even more relevant now than in 2006 when the CREST working group delivered its report.[7] On the other hand, it has become clear that tax incentives for R&D, however positive they might be, usually will be insufficient to increase the

[4] As measured by Gross Expenditures on Research and Development (GERD).
[5] For example, see Bruno von Pottelsberghe, *Europe's R&D: Missing the wrong targets?*, Bruegel Policy Brief, February 2008; and Andreas Schibany, *No More Appeals Please: The Lisbon Process and other Observations*, InTeReg Working Paper No. 51-2008, Joanneum Research, Institute of Technology and Regional Policy, July 2008
[6] Also the US President Barack Obama in a speech to the National Academies of Sciences on April 27, 2009 set a 3 per cent R&D to GDP target. http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=20090427
[7] France and the United Kingdom have made their tax incentives for R&D considerably more generous in the last couple of years.

level of R&D up to the 3 per cent goal alone, and need to be combined with other measures[8]. Tax incentives should thus be viewed as one of several complementary instruments. This is particularly the case for countries that already have schemes for tax incentives in place.

It should be noted that the objective of supply measures such as tax incentives and grants is to push companies to increase their R&D.[9] Another approach is to induce customers to demand more innovative products and services, and thereby pull businesses to increase their R&D. Public procurement of innovative products and services is an example of the demand approach.[10] Indeed public procurement could be a very substantial driver of innovation, and thus also of business R&D. The group has, however, not studied how well suited present tax incentives are for this type of public-private partnership.[11]

2.2 Tax incentives and the economic cycle

A major development since the CREST working group delivered its report in 2006 has been the current economic downturn. Although companies' response to difficult times varies, the overall effect is an aggregate reduction in R&D. This has been the case for the United States[12] and also for small open economies such as Norway's.[13]

The procyclical tendency of R&D investments seems unfortunate from a societal point of view. Aborting ongoing projects is a waste of economic resources, ultimately paid by society. And it makes sense to use available resources during an economic downturn to invest in innovation for the future. Quite a few companies pursue this logic. Many companies, however, tend to reduce their R&D efforts due to financial constraints and overall bleaker economic perspectives for investment in the future

[8] The situation in Norway illustrates this point. To reach the Lisboa goal, business R&D expenditure would have to more than double. With the present industrial structure such an increase would probably not be possible. And without the importation of substantial R&D resources from abroad, the country would probably not have the necessary capacity to increase its R&D effort so much for several years ahead.

[9] Most support measures subsidize the R&D effort, and not the successful outcome. Netherlands has developed a plan to introduce tax reliefs for patent income, which indirectly can be regarded as an R&D subsidy. Directing more of government support for R&D to the positive outcomes is an interesting development and deserves to be studied more closely.

[10] See, European Commission, *Guide on dealing with innovative solutions in public procurement comprising good practices, 10 elements of good practice*, 2007; See also http://ec.europa.eu/invest-in-research/policy/pub_procurement_en.htm.

[11] The main problem related to this type of public procurement seems in many cases to be that government agencies most often have few incentives to purchase other than what already exists in the market and often do not have budgets for involving themselves in this type of activity. The US initiative for developing a better lighting bulb is a brilliant example of a government innovation-pull. See http://www.lightingprize.org/

[12] Gadi Barlevy, "On the Cyclicality of Research and Development," *American Economic Review*, volume 97, 2007, pp. 1131-1164

[13] Norway's R&D was down by 8.5 % during the recession of 1987 according to published statistics from Statistics Norway

Will then enhancing the generosity of R&D tax incentives in economic downturns be a sensible policy measure? The impact on overall employment will likely be very limited. However, introducing more generous tax incentives may contribute to maintaining the level of R&D in difficult times. But it is uncertain whether improved tax incentives would be the most appropriate or a sufficient tool for addressing the problems R&D companies face in recessions.[14] Upstart companies with no ready products in their portfolio probably face the most serious problems. They are often financially constrained and dependent on outside capital. The venture capital markets and the market for initial public offering (IPO) have virtually dried up, although they now seem to a certain degree to revive again in some countries[15]. For startup companies, an improved R&D tax incentive will likely be insufficient. Subsidized loans or other forms of cash infusion seem to be more relevant than improved tax incentives.

For companies in a reasonable cash position, an improved tax incentive may have a positive effect on maintaining or even increasing R&D activities. However, some companies will maintain their R&D activities also in a recession without an improved tax incentive for doing this. Other enterprises may have compelling reasons to scale down or reorganize their R&D, and will not be much influenced by an improved tax incentive.

The relevant questions are how large the group of companies is that would be influenced by an enhanced tax incentive in a recession, to which degree the improved tax incentive would have an additionality effect, and finally what the total cost to government would be in relation to the volume of R&D that is upheld. The expert group is not aware of studies that shed sufficient light on these issues to formulate any policy advice. Under these conditions the expert group limits itself to suggesting that countries look carefully into the effect of the recession on R&D activities and set into place public measures that under national circumstances seem appropriate, without necessarily favouring enhanced tax incentives as a policy tool.

In addition, the expert group suggests a study of the impact of the economic cycle on R&D, and how differing tax incentive designs may influence this relationship. Better insight in this field may have policy implications for dealing with R&D funding in future economic downturns.[16]

2.3 Tax incentives and the location of business R&D

A number of countries are concerned about the level of business R&D and the slow growth of business R&D expenditures. It is therefore to be expected that the question of making tax incentives more generous is up for discussion. This question is all the more relevant as some

[14] The Netherlands has temporarily made its tax incentive more generous to maintain the level of BRD in the economic downturn

[15] The European Association for Bioindustries states that in the spring of 2009, one in four of small biotech companies had less than 6 months cash at hand. See, EuropaBio, *SME Platform, Access to finance: A call for action*, May 27 2009

[16] The OECD has already prepared its own assessment of the recessionary impacts on innovation. See, Dominique Guellec and Sacha Wunsch-Vincent, *Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth*, OECD Paris, June 2009 http://www.oecd.org/dataoecd/59/45/42983414.pdf

countries, like France, recently have adopted considerably more generous tax incentives, making it more attractive to conduct R&D in France than previously

Introducing more generous tax incentives will usually increase R&D expenditures by firms already located in the country. But, will more generous schemes in other European countries lead to an exodus of business R&D to that country, and vice versa, will improving tax benefits result in an influx of business R&D? And at the European level, if tax incentives indeed do influence the location of R&D, is this going to result in a *zero sum* game in the sense that R&D spending is relocated without any total increase in R&D? If the latter were the case, the effect would be loss of EU countries governments' revenue without achieving more R&D expenditure by firms. A number of these issues are dealt with in the paper entitled "*The effect of R&D tax incentives on location of R&D investment"* by Chiara Criscuolo (Annex 1).

There are very few econometric studies on the impact of R&D tax incentives on the location of R&D. On the other hand, there are many survey based studies on the impacts the general tax level has on the location of business R&D. These studies point to the fact that when businesses decide where to locate or expand R&D, taxation is usually not the most important factor. Market conditions, quality of workforce, infrastructure, stability etc are usually the dominant factors. All other conditions equal, the tax level could play a role as a determining factor. But in Europe, at any rate, conditions can vary substantially between countries. Studies of agglomeration effects indicate further that substantial tax differences can be maintained between regions because the benefit of locating in a particular region can be larger than the cost imposed by higher taxes. The question then becomes whether R&D tax incentives have an influence on the location of business R&D.

Surveys indicate that businesses take a number of factors into consideration when deciding where to locate or increase their R&D. For development work, closeness to customers and suppliers is important. For more advanced research, closeness to excellent academic research institutions, the quality of the work force and protection of intellectual property are important factors. R&D tax incentives, in general, do not seem to be very important factors.

In some multinational enterprises, with investment decisions centralized in corporate headquarters, especially, tax incentives are reported to have more significance in determining the location of R&D. To which degree this actually is the case, or reflects strategic answering, is not certain. If there is indeed a location effect of the tax incentives, the next question is whether this results in a net economic benefit or becomes a *zero sum* game. Assuming companies make rational economic decisions, one might expect that as R&D is relocated to a country with more favourable tax incentives, it lowers the cost of doing R&D to the firm. This can lead to greater R&D output in the long term.[17]

Two econometric studies in the field (Bloom and Griffith and Wilson), as cited in the discussion paper, both point to a small relocation of R&D due to changes in tax incentives. The study by

[17] Assuming that demand for R&D is elastic with respect to price (cost), this may increase R&D expenditures of that firm over the long term, compared to pre-relocation scenario.

Bloom and Griffith suggests that there will be a total increase in business R&D, whereas the study by Wilson indicates that there is a zero sum game, and that there will not be a total increase in R&D spending in the country. The two studies build on different datasets. Furthermore, the Bloom and Griffith study looks at international effects, while Wilson study looks at relocation between US states. The expert group's assessment is that the evidence of the location effect changes in R&D tax incentives is still scarce, and that there is not a sufficient scientific basis for firm conclusions.

Based on the discussion above and lack of conclusive evidence, the expert group suggests that countries first should base their policy decisions related to the generosity of tax incentives on national needs and objectives. There is furthermore no compelling evidence that indicates that the introduction of R&D tax incentives by EU countries will result in some zero sum game. At the same time, econometric evidence on the positive relationship between R&D tax credits and R&D investment at the level of single countries would suggest benefits to the European society when all member countries are taken together. In the short term however, the benefits would be reduced by relocation cost.

Overall, there is scant empirical evidence related to tax incentive's influence on the location of R&D. There are few studies that look at the issue in depth at a European level. A better understanding of the effects of tax incentives is relevant both for national and for EU policy in the future. The expert group therefore advises that the initiative is taken to study these questions more in depth.

3 Designing R&D tax incentives

3.1. CREST 2005 Working Group's advice on design

The mandate of the CREST working group covered the design and evaluation of R&D tax incentives. The group was given the task of producing a report that should "include guidelines for the design and use of fiscal measures and guidelines for the evaluation of fiscal measures, and if necessary, also propose further initiatives that could develop expertise in this field." The group produced a report and a handbook on the design and evaluation of R&D tax incentives.[18]

The group noted that a majority of EU members had introduced tax incentives for R&D, and that tax incentives were common also in other countries. A review of evaluations indicated that tax incentives do lead to more R&D. Based on the assumption that R&D is profitable for society as a whole, the group was positive to the use of tax incentives for R&D.

The working group did not advise countries whether they should or should not introduce R&D tax incentives. This was regarded as a policy issue that should be solved taking into consideration national circumstances which vary considerably. The group also expressed the opinion that there

[18] *Evaluation and design of R&D tax incentives*, Report of the CREST Expert Group on Fiscal Measures, European Commission, Brussels, March 2006. Also see, *Handbook on the Evaluation of R&D tax incentives*, 17 March 2006

was not one best design for tax incentives, as what is appropriate depends on the objectives set and other national circumstances

However, the working group emphasized the need for countries to carefully assess the economic rationale of tax incentives as part of the countries' R&D policy, the public costs related to the incentive, and how it should be designed to be most effective and efficient under national circumstances. The working group stressed the need to formulate clear objectives before designing a tax incentive.

The CREST working group did however give general advice on the design of tax incentives that countries were suggested to take into consideration when tailoring national incentives to the country's particular circumstances. This advice, based on past evaluations, members' experience and their observations and discussions in the group, is summarized in Table 1 below.

Table 1: CREST Working Group 2005: Summary of Advice on Design

Category of Advice	Description of Advice
G*enerosity of the scheme*	The generosity of R&D tax incentives varies among countries. This is not surprising in light of the differences in objectives and the total government support for R&D through direct assistance and tax incentives as a whole. Thus the design of a tax incentive must be relevant under national circumstances and be tailored to the policy objectives in the country.
Simplicity	Certainty, simplicity and consistency should be the guiding principles for the design of R&D tax incentives. This makes the tax incentives more transparent, easier to understand, and more predictable and stable over time. Simplicity will reduce administration and compliance costs for business and government and allow for better planning of business R&D strategy.
Differentiation	R&D tax incentives preferably should not differentiate between different types of production or services, but be open for all business sectors. Depending on national objectives, the tax incentive could be designed to support SMEs or start-ups, or, for example, be limited to research intensive firms (over some R&D intensity threshold)
Volume based and incremental tax incentives	If the objective of a tax incentive is to increase the overall level of R&D in the country, a volume-based tax incentive would be most appropriate. Incremental schemes may be considered where the objective is to support firms with high R&D growth. A combination of volume and incremental tax incentives (hybrid schemes) may be considered where the objective is to maintain the level and reward high growth of R&D. However, incremental tax incentives have the drawback of being rather complex to monitor their incremental use. In contrast, incremental schemes generally appear to be less of a burden to the taxpayer than volume based systems.
Eligible R&D and eligible costs	The attractiveness of a tax incentive will in part depend on what types of R&D and which costs are eligible under the scheme. The range of R&D as defined by the OECD in the Frascati Manual or in the International Accounting Standard

	(IAS 38) [19] should be covered by the tax incentive, if there are not particular national reasons for some kind of limitation. The tax incentive should regard purchased R&D as an eligible cost and cooperative R&D should benefit from the scheme. Wages for the research staff directly employed should be clearly eligible. As to other costs, direct material cost and capital asset costs (other than buildings) related to the R&D activity, and overhead costs allocated to R&D activity should cover some or all of such costs.
Administration of R&D tax incentives	The administration of tax incentives had not been given much attention in previous studies. However, the administration, which should be regarded as an element of design, has considerable impact on the uptake of the tax incentive and how generous the tax incentive in reality is. Rules and systems that are difficult to understand, uncertainty related to whether the tax incentive actually will kick in, and the possibility of burdensome reporting and possible litigation will act as deterrents for using the tax incentive. And the cost related to obtaining and retaining the tax incentive will reduce the value of the tax incentive. Thus it is necessary to keep the tax incentive as simple and transparent as possible and to establish effective dispute resolution process administrative in order to avoid costly litigation. Advance approval confirming that a project is covered by the tax incentive was mentioned as a useful possibility.

3.2 Comments and observations

3.2.1 Introduction

Since the CREST working group delivered its report in 2006, the trend has been a move to more generous schemes and new tax incentives for R&D and innovation, and more flexible EU state aid rules for support to business R&D. The countries seem to be gradually departing from complex hybrid schemes and are moving towards volume-based schemes (see box below and Annex 4 for summary of R&D tax incentives.)

[19] The Frascati manual is better known amongst R&D policy makers than the IAS 38. The IAS prescribes the accounting treatment for intangible assets such as intellectual property rights and know-how that are not dealt with specifically in other accounting standards. The IAS 38 thus contains a number of definitions that also could be used in legislation pertaining to tax incentives for business R&D. For further details, see Deloitte's presentation of the history and the contents of IAS 38 http://www.iasplus.com/standard/ias38.htm

Examples of notable changes to generosity of R&D tax incentives

France

The general tax-incentive scheme (Credit d'impot recherche (CIR), was altered radically in 2008. It now offers a refundable general volume based tax credit of 30 per cent with no cap. . For new companies, the rate is 50 per cent in the first year and 40 per cent in the second year. The previous scheme was a hybrid consisting of 40 per cent volume and 10 per cent incremental tax credit with a ceiling of 16 million euro per year. Overall, the scheme has thus been made much more generous.

United Kingdom

The tax allowance for R&D has been made more generous. It increased from 125 per cent to 130 per cent for large companies. For small and medium sized enterprises, the R&D tax allowance is 175 per cent, up by 25 percentage points.

Norway

Following a comprehensive evaluation, the cap on SkatteFUNN has been increased from NOK 4 million to 5.5 million for in house R&D and from NOK 8 million to NOK 11 million for R&D collaboration with research organizations.

Australia

A 40-45 per cent volume tax credit, replacing the current hybrid scheme is to be introduced by July 2010.[20]

United States

The US government has pledged to make the research and experimentation tax credit permanent.[21]

Comparing the generosity of tax schemes in different countries is not only a question of comparing the percentage rate of support offered and the corporate tax rate. One must *inter alia* take into consideration how broad the R&D definition is in law and in practice (eligible projects), and how the eligible costs are computed and whether there is a cap or other restrictions related to the amount of tax relief that actually may be obtained.

Most countries have different types of caps or ceilings limiting the amount of support that companies may receive. This might in some cases define not only the level of generosity but also the profile of the tax incentive. A low cap will, for example, imply that the scheme first of all targets small companies and has a limited impact on larger businesses that invest more in R&D.

Parallel to regular R&D tax incentive schemes, special and even more favorable schemes have been set up for young innovative companies in some EU countries. For example, in France, the

[20] Commonwealth of Australia, *Powering Ideas, An Innovation Agenda for the 21st Century, 2009*, pp. 46-47, http://www.innovation.gov.au/Section/Innovation/Pages/PoweringIdeasAnInnovationAgendaforthe21stCentury.aspx

[21] http://www.taxpolicycenter.org/taxtopics/2010_budget_RandE.cfm. The legislation is not yet in place.

research tax credit (CIR) and Jeunes Enterprises Innovantes (JEI) are not mutually exclusive. Under the JEI scheme it is thus possible to combine the tax credit with tax holidays on profits.

The European Union has adjusted its rules on state aid for R&D. The adjustments permit somewhat higher aid intensities than previously. In addition, through regulation 800/2008, EU has decided that member countries may introduce a wide range of support schemes for R&D without notification to the Commission.[22] These adjustments can indirectly be interpreted as expressing an understanding of the increased need for government support of R&D in order to stimulate European innovation. Although the rules mentioned here first of all are relevant for direct government support, they also apply to selective[23] tax incentives for R&D.

3.2.2 Previous advice in line with current developments

The expert group believes that developments since 2006 have *not* brought to light new facts, experiences or insights that may imply that the there is a need to revise the work on design of tax incentives done by the CREST Working Group. Recent reforms of tax incentives in several countries referred to above seem in general to be in line with the advice given by the group, thereby indicating that the advice was sound.

However, the expert group believes that strengthening the knowledge base for advice on designing tax incentives could lead to better schemes, giving the taxpayer more value for money Some suggestions for this are discussed below.

3.2.3 Generosity

The generosity is an important aspect of the tax incentive design. A meager tax incentive may not have much impact. An overly generous one can be unduly costly and can lead to some R&D that from a societal point of view should not be carried through.

The scientific basis for deciding how generous a tax incentive should be in different countries, and in relation to different goals, is in part lacking. At the core of the issue is the question of the value of increased business R&D to society, which should be higher than the cost of subsidizing it. This very much depends on the magnitude of spillovers from R&D. Spillovers are typically examined from a local and national perspective. As knowledge from R&D is mobile, spillovers can also have international dimension which may be of importance from the European Union's perspective. Thus in discussing the level of generosity of the R&D tax incentive, there is also a question whether only national effects should be taken into consideration or also international spillovers.

[22] European Commission regulation No. 800/2008 of 6 August 2008 declares certain categories of aid compatible with the common market in application of Articles 87 and 88 of the Treaty (General Block Exemption Regulation)
[23] Taxes fall outside the scope of the EU-treaty as long as they are not in conflict with the fundamental freedoms. However, exempting certain types of businesses or activities from general taxes is regarded as state aid. Such selective tax incentives for R&D may be permissible all the same, as long as the support does not exceed the limits that apply to direct grants under EU state aid rules for R&D support.

The expert group believes that it is important to strengthen the basis for decisions related to the generosity of tax incentives. The group suggests initiating further research into how the level of generosity is determined in various countries and what practices are involved in this process.

3.2.4 Generosity of tax incentives in relation to business-science cooperation

Several countries have extra generous tax breaks for business-university R&D collaboration (see Annex 5). The belief that such cooperation is particularly beneficial is also reflected in the EU state aid guidelines and rules related to support of business R&D. Thus collaborative projects may be given a higher level of support than other projects. In a discussion paper entitled *Tax incentives for industry-science R&D collaboration* (Annex 2), Dirk Czarnitzki discusses the relationship between R&D tax incentives and industry-science collaboration and presents an approach to the evaluation of such schemes in the future.[24]

The main rationale for government support for business R&D is market failure that leads to businesses conducting less R&D than what is beneficial for society. One of these market failures is due to the inability of firms to appropriate all their R&D outcomes. Knowledge will spill over freely to the rest of the economy. Such positive externalities will not be taken into account when a business assesses the expected profitability of a planned R&D project. Another failure relates to the financial markets that perceive investing in R&D projects as more financially risky than these projects are from a societal point of view. These factors result in businesses investing in less R&D than would have been beneficial for society. (See Annex 3 on financing constraints.)

It is not evident that market failures are good enough reasons for giving collaborative projects between businesses and universities and other public research institutions a bonus tax incentive. It might, however, be argued that cooperative projects will have higher research content and be closer to basic research than most of the R&D projects undertaken by business. For such projects, the knowledge leakage is more prevalent, the full appropriation of results more difficult and the risk higher than for other projects. These factors might be reason enough for a more generous treatment of collaborative R&D than projects a company handles on its own. The validity of the argument hinges on whether collaborative R&D projects, on average, indeed do have higher science content (and spillover benefits thereof) than other R&D projects.

Any public support of R&D entails the risk of crowding out private sector R&D expenditure (i.e., government funding replaces the private funding that will have taken place in the absence of government support). This could also be the case of business-university projects if they receive preferential tax treatment. The situation might be that businesses instead of conducting projects themselves enter into cooperation due to such treatment. Indeed, if this is the case, the tax

[24] The analysis includes a) the economic motivation for such tax-based policy instruments with respect to potential market failures of the type of research conducted within such public-private R&D consortia, b) the industrial economic literature on R&D collaborations which needs to be understood for future evaluations of such schemes, c) the existing empirical literature on policy measures and industry-science collaborations, and d) as literature on evaluation of such schemes is basically non-existent, the paper includes suggestions for future evaluations of special support schemes within R&D tax credit programs in European Member States.

incentive might produce economic inefficiencies, for example, by pulling university researchers away from their core responsibilities such as fundamental research and teaching, although the R&D could have been carried through by others.

Many governments have the goal of forging close relationships between businesses and universities as part of their science policy. The rationale for this may not only be to overcome a presumed market failure as described above, but also the belief that universities are producing knowledge more valuable to businesses than businesses actually are aware of. Empirical evidence suggests the presumption that businesses often seek cooperation with universities for more fundamental and long term projects. In the same vein, it is sometimes expressed that it is good for science to be more exposed to the practical needs of the business. Overall, these approaches might seem indeed to be a reflection of a failure in the knowledge transfer between businesses and universities, due to cultural and organisational barriers. To which degree this is the case, and whether tax incentives are appropriate for dealing with the problems, is not evident.

Preferential tax incentives for industry-science R&D cooperation have not been evaluated in depth. Little is known about whether they actually target market failures reasonably precisely, to which degree they have a crowding out effect, and to which degree they bring universities and businesses closer together in a beneficial manner worthy of the extra support from society. In addition, little is known about the transaction costs in cooperative projects, and thus how generous the support through the tax scheme should be to achieve the desired effects. On this basis the expert group suggests that an evaluation of tax incentives for business-university cooperation is initiated. The expert group believes that this possibly could be a joint evaluation for several European countries that have such special schemes in place.

3.2.5 Stability and simplicity

Stable R&D tax relief programs allow businesses for long-term planning of R&D investment. In contrast, overly complex schemes - or those which change frequently – may act as a deterrent to R&D investments.[25]

The expert group wishes to emphasize the following practices to ensure the credibility of tax incentives:

- When governments need to revise tax incentive rules, they should strive to shelter the already running R&D projects for a grace period from new rules that make the tax incentive less favorable.

- Any amendments to the tax incentive schemes should be developed in cooperation with the private sector. Cooperation ensures that otherwise well-founded modifications do not have unexpected side effects, and will contribute to finding solutions that reduce compliance costs.

[25] OECD, *Tax Incentives for Research and Development: Trends and Issues*, Paris 2001

Combining different types of tax incentives for promoting R&D investment might make the total support system in a country more complex and less stable than relying on one single system. Notably several countries have created very favourable tax regimes for young innovative firms (e.g. France, Belgium). Other countries have adopted tax legislations that give business angels, and in particular those investing in R&D-intensive firms, different tax benefits (e.g., the United Kingdom, Ireland, the United States and Canada (state and provincial levels).

The expert group believes that such schemes should be studied to understand how they work and interact with the R&D tax incentives in place, in terms of their efficiency and impact on the level of R&D and innovation.

3.2.6 Eligible projects and eligible costs

General issues

The CREST Working Group suggested that the definition of eligible R&D expenditure could follow either the Frascati manual definitions[26] or the IAS 38 definitions.[27]

The expert group wishes to point out that the R&D definitions in the Frascati manual and in IAS 38 are developed for statistical and accounting purposes. It is not evident that these classification systems in all respects are appropriate for legal and administrative purposes, or for identifying which projects and costs, from a societal point of view, should be covered by a tax incentive.

In order to make the schemes more business friendly, the use of definitions and appropriate keywords should furthermore be as precise as possible when applied to R&D projects. The expert group therefore suggests that a study analyzing the actual wording of tax incentives in relation to sound R&D-policy and good administrative practice be undertaken. Such a study could eventually lead to advice given to member countries for their drafting of business R&D tax incentives.

Services and the culture industries

The design of tax incentives usually focuses on industries in the traditional sense of the word such as, for example, manufacturing, biopharma, and information and communication technology (ICT). This point of departure has in most countries, and quite rightly so, influenced the definitions of eligible R&D and eligible costs.
Today, the service industries have become a large, dynamic and innovative part of the EU economy. Furthermore, the distinction between manufacturing and service industries has over the years become more blurred, as for example when suppliers of goods link their delivery to

[26] According to Frascati definition, R&D comprises: creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society; and the use of this stock of knowledge to devise new applications. R&D is a term covering three activities: basic research, applied research, and experimental development. See, OECD, *Frascati Manual*, Paris, 1993.
[27] For description see footnote 20

services. If innovations in the service sector are linked to R&D, such work should benefit from a tax incentive in the same way as the manufacturing industries. However, the expert group is uncertain about how well the present tax incentives suit the way innovations take place in the service industries. Furthermore, in some countries the service industries claim that the incentive schemes in place are not well suited for the type of R&D they conduct and how they innovate. The expert group has not been able to study this issue in any depth. The salient point is whether the service industries indeed do engage in R&D with positive spillover effects, which is not covered by tax schemes in place, either due to the wording of the scheme or to administrative practice.

Taking into consideration the growing importance of the service industry, the expert group suggests that tax incentives' appropriateness for the service industries should be studied. The outcome might be that real problems are detected, or that the discussion can be set aside as a misunderstanding relative to what R&D is and why it should be supported. If this suggestion is followed up, the expert group advises that the tax incentive's fitness for the cultural industries is included in the work. These industries, that today fall under different categories in national statistics and do not have a clear definition, are economically increasingly important.[28]

3.2.7 Administering tax incentives and complying with the rules

A precondition for the success of a tax incentive hinges on the uptake by business R&D performers.[29] The uptake can be heavily influenced by the efficiency of the government administration of the scheme. Administration and oversight of the tax incentive program consists of a number of activities that should result in the right projects receiving support in a user friendly manner, the claimants obtaining an appropriate follow up, the functioning of the scheme being effectively monitored and the design being improved according to experience. Government administration also includes outreach activities, building awareness and making the incentive accessible to prospective clients.[30]

It is important to underline that energy and attention used by businesses to obtain the benefit of a tax incentive, or involvement in control and litigation, divert intellectual capacity from R&D and innovation activities. The opportunity cost due to compliance burdens might be higher than the benefits received from the tax incentive. Attempts should therefore be made to keep the total administrative cost as low as possible, without compromising the scheme by making it easy to abuse. One creative effort that can be mentioned in this connection is that authorities in the Netherlands that deploy the tax incentive have nominated a number of companies as highly

[28] A recent study in Norway by Østlandsforskning showed that the cultural industries measured in terms of employees was more than 35 per cent of the manufacturing sector, see Haraldsen m.fl. KULTURNÆRINGENE I NORGE MULIGHETER OG UTFORDRINGER en oppdatering av kartleggingen fra 2004. The report can be obtained from http://www.ostforsk.no/

[29] Typically defined as number of applicants to the scheme or more narrowly a number of beneficiaries i.e. the companies whose claims have been approved

[30] This is often done through various instruments but most often through websites, information seminars for first-time claimants or using industry's own organizations for the promotion of the scheme.

trusted businesses. Such status allows these companies to file claims for the incentive without any further processing of an application.

Overall, a friendly access for eligible companies and effective awareness building process of the availability of the incentive are crucial preconditions to the success of the tax incentive.[31] Furthermore, it is important to establish procedures and mechanisms that avoid expensive litigation for the companies when disagreement with authorities arises. For these reasons, the expert group reaffirms the CREST working group's advice in this area, and suggests that the administration cost for government and compliance cost for business be given even more focused attention in design and evaluation of the tax incentive. These aspects indirectly affect the amount of R&D performed but are often overlooked in performance analyses. The expert group furthermore proposes that a benchmarking study is initiated, comparing R&D tax incentive programs internationally and identifying good administration and compliance practices.

4 Evaluating R&D tax incentives

The CREST Working Group dealt extensively with issues related to the evaluation of R&D tax incentives. This was followed in 2008 by the Expert Group on R&D Tax Incentives Evaluation. The group was established to suggest ways of improving the evaluation of R&D tax incentives in practice, and to help increase coherence among the evaluation methods used by EU member countries. The 2008 expert group did this through its own studies, by producing discussion papers on outstanding issues and arranging a seminar on the topic.

These two sets of advice are briefly summarized below and followed by current expert group's observations.

4.1 The CREST Working Group's advice on evaluation

The following principles were identified by the CREST WG 2005 and recommended to policy makers involved in the evaluation of R&D tax incentives (see Table 2). These are largely drawn from the conclusions presented in the Evaluation Handbook:[32]

[31] It can be regarded as a small defeat when, for example, companies in Norway to a certain degree hire external consultants to get an approval for their projects , because this might indicate that the tax incentive is not sufficiently user friendly and easy to use. In Canada, industrial R&D performers also very much rely on outside consultants, which can claw back substantial amount of the claim

[32] *Evaluation and design of R&D tax incentives*, Report of the CREST Expert Group on Fiscal Measures, European Commission, Brussels, March 2006. Also see, *Handbook on the Evaluation of R&D tax incentives*, 17 March 2006

Table 2: CREST Working Group 2005: Summary of Advice on Evaluation

Evaluation principle	Description of Advice
Clarity of objectives	The aim of an evaluation should be to ascertain whether the tax incentive has been a success in relation the scheme's objectives, and why it has or has not met its targets. There is a need for ensuring that the objectives of a tax incentive are formulated as precisely as possible in advance. Clarifying the objectives is often necessary for evaluation data are gathered. Clarity will help policy makers responsible for deploying because they will know their objectives better.
First order effects (direct additionality)	Evaluations as a minimum should focus on ascertaining to which degree they induce more R&D (over and above what would have taken place otherwise). Firm-level economic benefit of the increased R&D effort should also be evaluated. This may be, for example, measuring the impact on firm's competitiveness and profitability. If the evaluation does not cast light on these effects, it will not contribute to understanding whether the incentive meets its main objective or not. Although it is easy to state in principle what should be evaluated, getting precise answers is far more difficult. The reason for this is the counterfactual problem: It is not possible with 100% certainty to say exactly how the R&D effort had developed without the tax incentive. Evaluations will for this reason only be able to give a more or less certain indication of the incentive's effect. Secondly evaluations will have to depend on statistics and surveys, which will be more or less trustworthy and complete.
Second order effects	A tax incentive could change the way a firm deals with R&D. Such changes could have long lasting effects that will not be picked up through direct additionality of R&D. Such effects can be related to the company's R&D and innovation strategy, alertness to scientific and technological developments, collaboration with other firms and research institutions, and effects on the human capital in the firm. These effects can be both negative and positive for the firm or industry. Evaluations of behavioral additionality will to a large degree have to be based on surveys, and will be dependent on who the interviewees are, and whether they have any factual or psychological reason to exaggerate in any direction.
Third order effects	These third order effects might be substantial. However, it is virtually impossible to link them directly to a tax incentive for R&D. The causal relationship between what happens at the firm level and the total factor productivity in society is elusive and intertwined with many other factors, not least of all the importation of knowledge and technology from other countries. Because of this, the group advised *against* including third order effects in the evaluation of R&D tax incentives. This did not imply that the group believed that third order effects were unimportant. The reason for its advice was that such effects induced by an R&D tax incentive hardly could be isolated, but had to be studied together with other policies to promote innovation and learning, and that it was hardly realistic to isolate the effect of one single tool on total factor productivity.
Specific objectives	Although the general objective of a tax scheme is to increase R&D, a tax incentive may also have several additional goals. A usual intention is to selectively support SMEs or start-ups. Another goal could be to induce businesses to take their first steps

	in the field of R&D. Some tax incentives are motivated by the wish to induce R&D collaboration between firms or with research institutes. An evaluation of a tax incentive with such particular goals should also cover the question of whether such specific objectives have been fulfilled. It goes without saying that this also should include the cost and benefits of reaching the specific goals.
Integrated methodological approach	An evaluation can be based on different datasets and approaches. An evaluation, where possible, should attempt to apply several evaluation methods, and use the different results that might appear to draw up a nuanced picture of the effect of the tax incentive.
Data identification	Reliable data are necessary for a successful evaluation. Survey data can be gathered as part of the evaluation. But statistical data that show the development over time can not be created at the spur of the moment, but must be gathered over several years in advance as part of the preparation of an evaluation. When designing R&D tax incentives, the policy makers at the same time should decide to have the scheme evaluated, clearly identifying which data will be needed for future evaluation, and how to collect this data. The data should preferably allow counterfactual analysis when estimating additionality. Comparisons with developments in other countries with a similar industrial structure could in some cases also be relevant.
Independence of evaluations	An evaluation is usually undertaken to ensure that the tax incentive is functioning as expected, both in relation to the stated objectives and that it offers society good value for money. An evaluation should be used as a basis for the discussion of whether scheme should continue as before, be modified or be terminated. A number of players can have vested interests in the outcome of an evaluation. It is therefore important that the evaluations are of high professional quality. All the stakeholders should be confident of the impartiality of the evaluators. Thus careful attention should be given to the independence of evaluators and evaluation processes.

4.2 Advice of the Expert Group on R&D Tax Incentives Evaluation

The Expert Group on R&D Tax Incentives Evaluation (2008) was set up to address the issue of increasing coherence of methodologies used for evaluating the effectiveness of R&D tax incentives in Europe. The intention was to help facilitate the comparison of evaluation results and foster mutual policy learning among member states.

On the basis of the studies and material the evaluation expert group had at hand, it identified good practices and sought ways for improving the evaluation practice of R&D tax incentives.[33] The group supported the CREST finding that there is no single best way to conduct an evaluation of a tax incentive. This is because evaluations tend to reflect the country's specific economic structure, social values, political environment and evaluation traditions and expertise. Still, the

[33] European Commission, *Comparing Practices in R&D Tax Incentives Evaluation*, Expert Group on R&D Tax Incentives Evaluation,, October 2008, http://ec.europa.eu/invest-in-research/pdf/download_en/rd_tax_incentives_expert_group_report2008_rtd_final1.pdf

EG 2008 was able to identify the common areas of good practices that could contribute to successful evaluations. (For summary, see Table 3)

Table 3: Expert Group R&D Tax Incentives Evaluation 2008: Summary of Advice on Evaluation

Evaluation principle	Description of Advice
Planning for evaluations	Decisions to evaluate tax incentives often are based on an ex-policy need and less often as an upfront commitment. However, an upfront commitment to evaluate provides an opportunity to think about the evaluation requirements ex-ante, and in particular to ensure that the necessary data are collected. An early planning also helps to generate constructive interest and involvement of stakeholders. There is a need to plan for evaluations well ahead of the evaluation.
Ensuring access to data sources	Availability of good quality data is of the utmost importance for a successful evaluation. However, reliable and preferred data will often not be in place. The choice of evaluation method in many cases will be determined not by what ideally is best, but by the data at hand. Lack of data in some cases could lead to a postponement of the evaluation until sufficient statistics were in place and would make it difficult to present a timely and policy relevant evaluation.
Assessing additionality	R*aison d'être* of a tax incentive is to increase firms' R&D investments. Thus assessing the R&D additionality has to be an essential component of an evaluation. Investigating how many units of additional R&D expenditure are generated by one unit of the tax subsidy is therefore common to virtually all evaluations. But the precise calculations of the cost-effectiveness are not always comparable from one evaluation to another. Greater coherence between evaluations would be useful when comparing tax incentives in different countries. This could be an area for further work.
Choosing evaluation methods	Structural econometric approaches are an effective methodology for estimating additionality. They can be usefully complemented by quasi-experimental methods based on discontinuities in the tax scheme and other more descriptive econometric exercises, and by survey evidence. Econometric evaluation methods depend on the availability of sufficient statistical microdata. Other approaches can also be pursued. The group referred to the partial equilibrium model used in the Canadian 2007 evaluation that was based on variables such as incrementality ratios and external rates of return (spillovers) from review of the literature.[34]
Determining spillovers	Existence of R&D spillovers is key justification for government intervention. However establishing the precise magnitude of R&D spillovers and welfare gains is very uncertain.The existing range of estimates is much too wide to provide a basis for specific policy decisions. There is a need for more work on spillover estimates of R&D tax incentives.

[34] Parsons, M. and N. Phillips, *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development*, Department of Finance Canada, Working paper, 2007, www.fin.gc.ca (available on request)

The 2008 expert group concluded that making evaluations as comparable as possible would be useful. Using similar data, the same evaluation methods, and the same metrics for calculating additionality and net welfare gains, would cast light on the relative effectiveness of different R&D tax incentive designs and hence improve policy design and implementation. In practice, comparability is limited by differing policy contexts in the countries, the lack of comparable data and the choice of different evaluation methods.

Following these observations, the EG 2008 identified two areas which tend to be overlooked and may benefit from additional future research. As a possible new theme for evaluation, the group highlighted the impact of different designs of R&D tax incentives on firms' decisions to start doing collaborative R&D with universities and the impact of R&D tax incentives on location decisions and how they affect innovation. The group added that it may be important to assess the impact of R&D tax credits in the context of other incentive schemes such as direct subsidies.[35]

4.3 Comments and observations

4.3.1 Introduction

While the current expert group generally agrees with the advice on evaluation given by CREST and by the 2008 Expert Group on evaluation, it has identified areas where the existing guidelines and advice can be supplemented. These are presented below.

Before dealing with specific issues, the expert group suggests that it might be useful to distinguish between what should be covered by evaluations of tax incentive schemes and what should be studied in a broader context.

Assessing the impact of a tax incentive on the overall productivity in society is a much broader challenge than finding out the isolated effects of a tax incentive. Such studies would have to take into account a very broad range of factors that affect total factor productivity in society, and would be dependent on good quality statistical databases. The expert group believes that there is a strong need for understanding how the innovation system in a country functions and how it can be improved, and which place an R&D tax incentive should have in this wider picture. The expert group, however, suggests that the term "evaluation of tax incentives" should not include such broader studies, for example, of the innovation system or economic growth, in general.

4.3.2 Appropriate scope of evaluation

In some countries, tax incentives consist of a main general scheme, supplemented with additional features. An example of this is a hybrid scheme which combines volume and incremental tax credits. Another example is topping the general tax incentive with a premium for collaborative R&D or for just being a small company. Such combined schemes may imply a need

[35] This advice has been followed up by the Commission in so far as the present expert group has been requested to study the effects of tax incentives on R&D collaboration and on location of R&D investment

for a comprehensive evaluation that may have to consist of several studies using multiple lines of inquiry, like in the case of Norway's evaluation or Netherlands' evaluation.[36]
The expert group sees the need for studying all aspects of a tax incentive. However, the expert group believes that practicality should take precedence before comprehensiveness and that evaluations should focus on selective issues that are important to pursue from a policy perspective. In planning the evaluation, the expert group suggests that planners develop variants of evaluation (i.e., from most comprehensive to leanest in scope) and choose the most cost-efficient variant that is able to meet the desired policy objectives.

4.3.3 Evaluation experience

The CREST Working Group suggested that countries might consider establishing a network to share experiences and examples of good practice in the design and evaluation of R&D tax incentives. This idea has been followed up by establishing expert groups in 2008 and 2009 to continue work in the field and arranging seminars as part of the background for the groups' deliberations and proposals.

The expert group suggests that this work continues after having inquired whether member countries are interested in doing so. A possible approach could be to get member countries to name experts to participate in a network for the design and evaluation of tax incentives. The network could meet at least once a year to exchange insight and experiences, and to initiate further studies and other types of cooperation that might be called for. An internet site could be established, gradually building up a library of tax schemes in place, evaluations, literature in the field and possibly also news in the field.

4.3.4 Administration efficiency

The expert group believes that regular evaluations of the administrative aspects of running a scheme for tax incentives are important. The aim of such evaluations would be to avoid unnecessary compliance costs for business and increase the uptake of the tax incentive, and at the same time find a balance between maintaining the legislative integrity of the incentive and keeping the total administrative cost as low as possible. Such periodical evaluations should cover both government and business costs of operating the scheme. The evaluation of the administrative efficiency could be an element in the evaluation of the overall effects of the tax incentive, or take the form of a separate evaluation. It is important to ensure that administrative adjustments that may emanate from the evaluation and that make sense from an administrative perspective do not contradict the overall objectives of the tax incentive.[37]

[36] Haegeland, T. and J. Moen, *Input additionality in the Norwegian R&D tax credit scheme*, Report 2007/47, Statistics Norway 2007; and de Jong, J.P.J. and W.H.J. Verhoeven, *Evaluatie WBSO 2001-2005. Effecten, doelgroepberiek en uitvoering*, Opdracht van het Ministerie van Economische Zaken, DG Innovatie, Netherlands, 2007

[37] After a review of the deployment of the Norwegian SkatteFunn tax incentive, it was discovered that small companies, in some cases, included excessive wages paid to the owner as an R&D cost, undoubtedly abusing the system. Without consulting the business community, there a cap was set on the highest hourly rate that would be an eligible cost. The rate was lower than normal total costs for an engineer in business. Although the cap made sense

4.3.5 New evaluation approaches

When estimating direct and indirect additionality, the main challenge is to establish datasets that make counterfactual analysis possible. According to the expert group, no matter how much effort is put into counterfactual analyses, it will not give any final proof of the incentive effect, but only reduce uncertainty surrounding the effectiveness of the incentive.

Evaluations attempt to answer which overall effects a tax incentive has, but rarely address questions related to the contribution of different design elements to the scheme's success or failure. An example is the impact of R&D tax incentives on industry-science collaboration, the topic discussed in Section 3.2.4 of the report and in Annex 2. It is interesting to note that although such collaboration has been extensively promoted, the group has not found any evaluations of the effectiveness of additional tax credits for projects that are undertaken with the involvement of public science.

The expert group suggests that a study is initiated to identify methods that could be used to gain more insight into these and other evaluation questions. Such methods could possibly include predictive or simulation models to study the effects of modifying design elements compared to the findings of the evaluation. Simulation models could also take the form of "laboratory experiments" where stakeholders' reactions to modifications of a tax incentive are observed. A development in this direction could make evaluations more policy relevant than today, and could be a contribution to strengthening the knowledge base for policy decisions in the wake of an evaluation.

Finally, the expert group takes note of a new approach to evaluations based on meta-analysis of previous evaluations, which seemingly avoid the counterfactual analysis problems.[38] A meta-evaluation utilizes in a single cost-benefit equation average or median estimates (parameters) representing the cost of tax distortions due to financing of R&D tax incentives, administration and compliance costs and spillovers in order to arrive at the net economic gain/loss to society per euro of tax subsidy. Although tempting in terms of lower cost and faster turnout of the findings, the expert group cautions against being overly reliant on such analyses, which depend on variables collected extraneously. Such cost-benefit approaches very much depend on the magnitude of spillovers and their credible estimation.

4.3.6 Credibility of evaluation

The credibility of an evaluation depends on the evaluators' independence. The parties responsible for design and administration of a tax incentive should naturally enough not evaluate themselves.

from an administrative point of view, it reduced the value of the tax incentive, which was not the intention of policy makers.

[38] An example is Canada 2007 evaluation, where partial equilibrium framework treats endogenous variables such as the cost of R&D or returns to R&D as exogenous. It also excludes some potential channels of influence, such as payments to foreign factors and terms of trade effects. See Parsons, M. and N. Phillips, 2007 (footnote 33).

On the other hand, the expert group believes that a credible evaluation should involve all stakeholders for three main reasons. First, they may contribute a valuable insight that is important for the design of the evaluation. Second, stakeholders will in general be more critical to the conclusions drawn from the evaluation than the evaluators themselves. Third, when government is going to decide which consequences the evaluation should have, it is important that stakeholders are well acquainted with the basis for the conclusions and have had a possibility to speak their mind.

5. Conclusions and directions for future research

The expert group views the tax incentives for business research and development as useful tools for national R&D policy. This is in accordance with what has been expressed by previous expert groups established by the European Union, and it is also the prevailing view in most countries. Several countries have in recent years made their tax incentives more generous and introduced new elements in them. Even countries with a high level of business R&D spending as a proportion of GDP, notably Germany and Finland, that previously have opted for direct subsidies only, are currently considering the introduction of tax incentives. The reason for the tax-incentives' popularity is that they work well, do not pick winners, and involve less paperwork in their reaching out to the business community.

Countries are well advised to ensure the smooth operation of their schemes for R&D tax incentives. The expert group suggests that countries carefully assess their tax incentives in place, and consider whether they should be made more generous, and whether new elements, for example special treatment of young and innovative companies, should be introduced. The expert group however underlines that any modifications of the tax incentive scheme should be based on careful analysis of the benefits to society and the costs to the taxpayer, and should have clear objectives. The evaluation of changes should be planned in parallel with the introduction of new rules and elements.

It should be noted that a number of countries have the ambition to substantially increase the level of business R&D. Tax incentives for R&D will, however, in most cases be not sufficient to fill the gap between today's level of business R&D and the goals for the future alone, and must be combined with other measures.

There is limited evidence that R&D tax incentives produce economic distortions between countries. The expert group therefore believes that member countries can maintain or design their tax incentives on the basis of national ambitions. However, the group advises countries to consider whether any changes of the tax treatment of business R&D might have a negative impact on European R&D as a whole, and to take such possible adverse effects into account when adopting new rules.

Although no need for EU harmonisation of tax incentive policies is perceived, the expert group believes that it would be useful for member countries and for the European Union to further strengthen the knowledge base for sound decisions in the field of design and evaluation of tax incentives. To this effect the expert group has come up with several suggestions for future studies and new directions in tax incentives' research. The expert group's suggestions are summarized in the box below.

Future Directions for Additional Research

1. Strengthening the knowledge base for policy decision related to the generosity of R&D tax incentives and their optimal design, in particular

2. Understanding better how R&D tax incentives interact, in terms of strengths and weaknesses, with other tax incentive schemes, such as Young Innovative Companies or tax preferences for angel investments in R&D firms

3. Assessing how well R&D tax incentives suit the R&D needs of rapidly evolving service industries, with a particular focus on emerging culture industries

4. Focusing attention to the administration and compliance costs of R&D tax incentive schemes by initiating a benchmarking study, comparing R&D tax incentive programs internationally and identifying good administration and compliance practices

5. Providing better insight on the relationship between the economic cycle and R&D and how R&D tax incentives and their different designs may influence this relationship

6. Understanding better the relationship between R&D tax incentives and the location of R&D in EU context by launching an impact study

7. Understanding better the impact of R&D tax incentives on science-industry R&D collaboration by launching evaluations into this outstanding area of impact assessment

8. Continuing the previous expert groups' work to date through establishing a network for the design and evaluation of tax incentives, in consultation with member countries

Annex 1

The effect of R&D tax incentives on location of R&D investment

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Introduction

Governments across developed and developing economies try to encourage firms to invest in Research and Development (R&D) using financial and fiscal incentives. The reason is that the returns to investment in knowledge and innovation cannot be fully appropriated by innovating firms as knowledge is a public good that can 'spill over' to others. Due to these externalities, the level of private R&D investment will be below what would be socially optimal.

Spillovers are generated from private firms' R&D and firms can therefore benefit from the presence of more innovative and more productive firms. There is now widespread evidence that multinationals are both more innovative and more productive than the average domestic firm. This is the rationale for policies to be aimed at attracting foreign firms.

In a world where multinational enterprises (MNEs) are increasingly internationalising their R&D activities, governments also compete in attracting R&D activities of multinational corporations which would have a high value added content and a strong knowledge spillover potential. The rationale is that generous incentives (e.g. a generous R&D tax incentive system) might make a country a relatively more attractive location for R&D investments than its competitors and that the forgone tax revenues would be compensated by the benefits accruing to the local and national economy from receiving the Foreign Direct Investment (FDI) both through increased employment, value added and localized knowledge flows.[39]

Understanding whether these policy measures have a significant impact on the location of multinationals' R&D investment is therefore becoming increasingly important since (national or local) governments' decisions on the introduction or modification of innovation support programs have the additional aim of attracting the increasingly mobile R&D investment projects by multinational corporations. Recently, several countries have made their R&D tax incentives more generous to be more attractive to foreign firms. For example, in Europe, France has recently changed

[39] The economic geography literature has stressed the importance of localized knowledge spillovers (LKS). Some researchers (e.g. Breschi and Lissoni, 2001) have stressed that more than pure externalities, local knowledge flows are actually mediated by economic mechanisms, .local markets, but do not dispute that knowledge flows are an important agglomeration force.

from an incremental tax credit system to a volume base scheme[40] ; Finland will likely introduce a tax credit scheme.[41]

Even though the impact of tax incentives on the international location of innovative activity of MNEs is an important policy question, very little quantitative analysis of this issue exists at present. More generally, evidence on the determinants of the location of R&D activities is mainly confined to evidence from survey of MNEs. The main reason for this paucity of evidence is due to a lack of suitable firm-level data on the location of innovative activities across countries.

This paper will provide evidence of the increased level of internationalization of R&D, review the literature on the determinants of R&D activity location focusing on the role of tax incentives and provide some policy conclusions and suggestions for further research on these issues.
The paper is organised as follows, in the next section we review the evidence on the increasing internationalisation of R&D activities by multinational corporations. In section 3 we are going to discuss the evidence on the determinants of the location of innovative activity. In section 4 we are going to review the studies on the importance of tax incentives and financial incentives for the location of R&D investments. Finally Section 5 concludes.

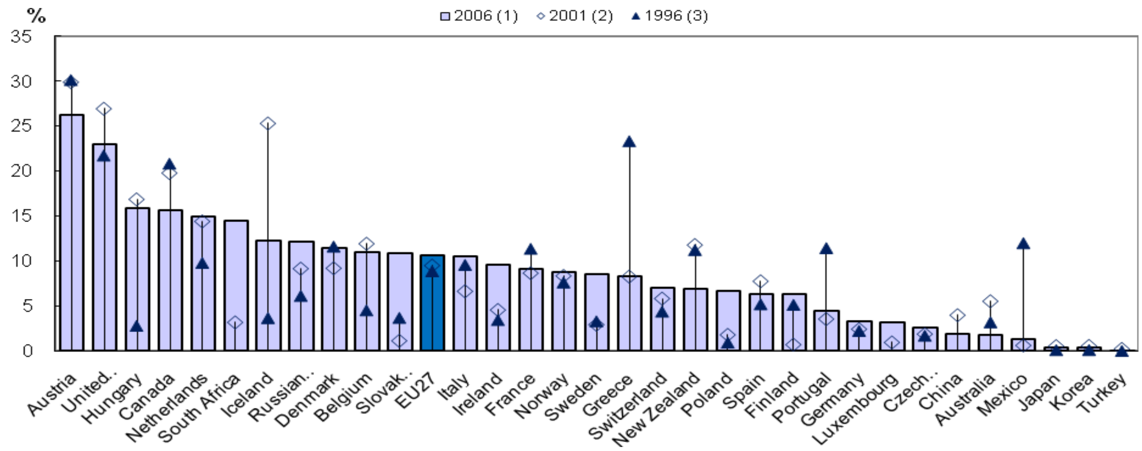
Internationalization of R&D: the evidence

The internationalisation of R&D has been taking place at an increasingly faster pace in the last few years relative to previous decades. Moreover, new destinations such as China and India are playing an increasingly important role. We present below some evidence that confirms these trends.

A first measure to use to investigate R&D internationalization is the share of a country's business R&D sourced from abroad. Figure 1 shows that in 2006 in the EU 27 countries Business R&D sourced from abroad represents on average 11% of total business R&D. Within the EU the highest shares are found in Austria (26%) and the UK (23%) while the lowest in Luxembourg and Czech Republic with shares of less than 5%. The figure also shows that on average in the EU27 countries the share of R&D funds from abroad has increase between 1996 and 2006, even though a comparison across countries shows some heterogeneity in the trends.

[40] "This measure proves France's commitment to increasing innovation. Many companies – both French and foreign – will benefit from this important incentive, which will also help attract major research oriented businesses in France," says Philippe Favre, President of the Invest in France Agency (from http://www.investinfrance.org/uploads/files-en/07-12-17_145649_CP_CIR07_EN.pdf)
[41] In the Appendix we report a summary of tax incentives schemes in selected nations from http://www.investinamericasfuture.org/PDFs/newRDchartRev04-04-08doc1.pdf on October 12th 2009 and http://www.ibm.com/ibm/governmentalprograms/global-rd-incentives-2008.pdf .

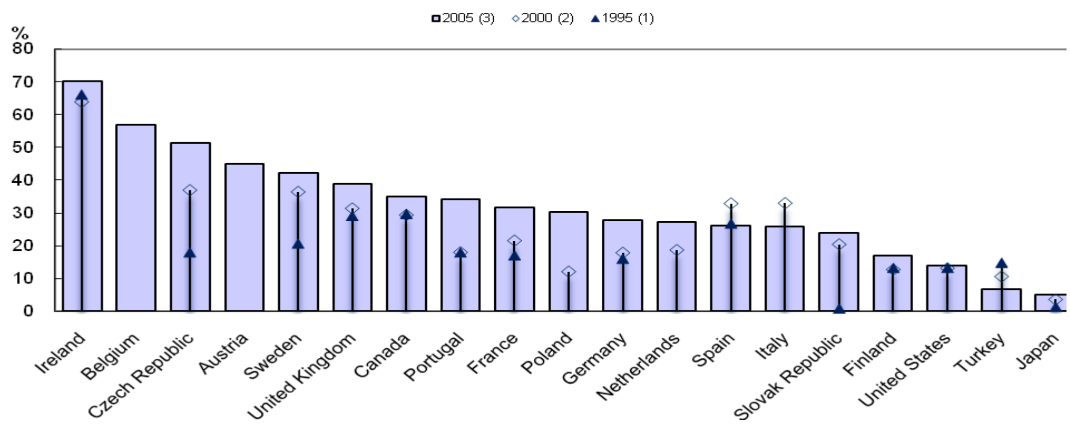
Figure 1: R&D funds from abroad, 1996, 2001 and 2006 (as a percentage of BERD)



Source: OECD STI Outlook 2008

A second way of capturing the increased internationalisation of R&D is to describe the increased importance of foreign affiliates in industry R&D. Within Europe the largest share of R&D expenditures by foreign affiliates are in smaller economies, such as Ireland, Belgium and Czech Republic with more than 50% of R&D expenditures by foreign affiliates, followed by larger open economies such as Sweden and the United Kingdom as shown in Figure 2.

Figure 2: R&D expenditure of foreign affiliates, 1995, 2000 and 2005



Source: OECD STI Outlook 2008

A third way to investigate internationalisation of R&D activity is to look at patenting activity of firms. Recent efforts by the academic community have lead to the availability of a dataset that matches firm level accounting information to the firm ownership structure and to the patents applied for at the European Patent Office (EPO) by these firms and their subsidiaries (see Abramovsky, Griffith, Macartney and Miller, 2008). These data gives a detailed picture of the increased internationalisation of R&D activities across fifteen EU countries. In particular, the data shows patterns very similar to the ones observed in the R&D expenditure statistics: the matched firm accounting - patent data show that an increasing number of patents owned by

European multinationals are associated with inventors based abroad. When looking at the innovative activity located in European countries, the data shows that amongst the firms associated with inventors located in a particular country the share of foreign multinationals is above 40% in some EU countries such as Belgium, Spain and the UK but remains well below 20% in others, such as Germany, Denmark and Finland.

Fourthly, a valuable source of information that has provided most of the existing evidence on the internationalization of R&D and the location of innovative activities by multinational firms across different countries comes from direct surveys to multinational corporations (see for example the work of Belderbos 2003, and Gastsby and Gatsby, 2006). We will discuss the evidence from these surveys regarding the determinants of the location of R&D below. Finally, very few countries have administrative microdata that contain information on the location of R&D activities of affiliates of domestic multinationals, for example Sweden, Japan and the US.[42] More recently, commercial microlevel data is available that identify the new location of multinational firms for different functions (production, headquarter and R&D) across EU countries since the late 1990s (see Defever, 2006). However, the exploitation of similar data remains still relatively unexplored. We will discuss some of the work that has exploited this information below.

Location of R&D: the determinants

Most studies on the determinants of the location of R&D activities are based on surveys to multinational corporations or on the analysis of "administrative" data of single countries. A survey of this evidence seems to suggest that the two main determinants of location are access and support to local markets, i.e proximity to other corporate activities, and proximity to local customers and access to local science and technology (e.g. Thursby and Thursby, 2006; von Zedtwitz and Gassman, 2002; Belderbos, 2006 and Kumar, 2001). In fact the international business literature generally distinguishes between home-base-augmenting and home-base-exploiting foreign R&D activities (Kuemmerle, 1997). *Home-base augmenting* laboratories aim at creating knowledge and transfer it back to the central R&D site; for these R&D labs access to frontier research, closeness to centres of excellence and the availability of a skilled workforce, engineers and scientists are particularly important. *Home-base exploiting* R&D labs on the other hand transfer knowledge from the multinational R&D centre – in the home country or in other home-base augmenting R&D lab - to the host country lab to commercialize that knowledge. For these laboratories closeness to other corporate activities (e.g. production) and to local customers is particularly important.

Similarly, in their survey of 1021 R&D sites owned by MNEs from different world regions, Von Zedtwitz and Gassman (2002) distinguish between the location determinants of Research and those of Development sites. Amongst the reasons to locate Research in a particular location (defined as science and technology drivers) access to local science and absorption of know-how

[42] We will discuss below the study of Foley et al. that use such US administrative data.

of global values are particularly important; amongst the reasons to locate Development closeness and cooperation with local customers and production are particularly important.

In their survey of over 200 American MNEs across 15 industries on the determinants of the location of R&D personnel Thursby and Thursby (2006) get to similar results. They find that location decisions are complex and affected by many factors. However, they suggest that four host country characteristics are extremely important: (1) output market potential, (2) quality of R&D personnel, (3) university collaboration and (4) intellectual property protection (IPR). Furthermore, they distinguish between determinants of location in developed and developing countries since they find that these are driven by different factors. Location in emerging economies is driven mainly by market growth potential; quality of R&D personnel; low costs of R&D and expertise of/collaboration with universities while it is hampered by weak IPR. Location at home and in other developed countries is spurred by the quality of R&D personnel, the strength of IPR protection and finally by the opportunity of collaboration with universities. Also, firms seem to be more likely to conduct potentially important R&D in developed economies while in developing countries - where IPR are weaker - firms tend to focus on improving existing technologies. Finally, an important result of this survey is that the majority (more than 70%) of new R&D sites abroad represent an expansion of existing R&D facilities (at home) rather than "relocation". Interestingly, tax incentives are not found to be an important determinant of multinationals' decision to locate R&D in a particular country. Thusby and Thursby find that amongst factors taken into account when selecting a site in an emerging economy tax breaks and/or direct government assistance[43] are not important in deliberations on the selection of the site and firms tend to disagree that the factor is important for emerging economies. They investigate the issue further and find that only 3 out of 80 multinational firms (3.8% of respondents) valued highly the importance of tax breaks and direct government assistance and agreed that they had been offered such incentives. Thursby and Thursby therefore conclude (p.24): *"Thus, one can reasonably reject the argument that tax breaks and/or direct government assistance are luring firms to establish R&D facilities in developing or emerging economies."*

Responses on the decision to locate sites in developed economies outside the home countries show again a low level of importance for tax breaks but here the answers are much more heterogeneous: about 24% of respondents both agreed that they had received incentives and that they were an important factor in the choice of the site. Thus, Thursby and Thursby conclude that tax breaks are more prevalent in developed economies.

One of the main worries when using results from surveys is that multinational firms would report strategically about the determinants of their investment location. In particular one might worry that when surveyed by government and tax officials they might report that tax incentives and government support in general are a strong determinant of their decision to invest in a particular region/country. On the other hand, when surveyed by other organisations they might downplay the importance of tax incentives and government support, in order not to look too opportunistic.

[43] A similar result also holds for the case in which the establishment of an R&D facility was a regulatory or legal prerequisite for access to the local market.

Therefore, we turn to econometric evidence to find additional support to the findings highlighted by the studies that use survey evidence.

How does the econometric evidence relate to the results of direct surveys to multinationals such as those presented above? The importance of universities as a driver of location found in the survey of Thursby and Thursby (2006) and that of von Zedwitz and Gassman (2001) is confirmed in more recent econometric studies (e.g e.g. Abramovsky, Harrison and Simpson, 2007 and Belderbos, Leten and Suzuki, 2009 and Alcacer and Chung, 2007). All of these studies show that the presence of universities – especially if they are centre of excellence - is strongly correlated with the location of MNEs' R&D laboratories in a region. Interestingly, they achieve this same conclusion using different data for different countries and different time periods and different econometric methodologies.

In a recent paper, Branstetter, Fisman and Foley (2006) confirm the important role of Intellectual Property Rights not only for the location of innovative activities of multinational corporations, measured both as R&D expenditures and foreign patent application, but also for the international technology transfer, measured as royalties payments, to affiliates of US multinational corporations. They find that legal reforms that strengthen IPR[44] in host countries over the period 1982-1999[45] lead to an increase in R&D expenditure and in technology transfer to multinational affiliates operating in reforming countries and that these effects are particularly strong for affiliates of US MNEs that use US patents extensively prior to reforms.

The study by Defever (2006) looks at the determinants of (co-)location of different functions of MNE firms and complementarities across functions. When regressing the entry of a new R&D lab in the EU on country characteristics he finds – we believe in line with survey evidence and with the study of Branstetter et al. – that judicial quality and market potential are significant explanatory variables. However, the most interesting result is the importance of both "functional agglomeration economies"[46] and of co-location of production activities by the same firm as determinants of R&D location. The latter result is in line with the New Economic Geography idea that multinational firms are likely to co-locate functions in the same country to exploit vertical linkages between different stages of the value chain and save on coordination costs (Krugman and Venables, 2005).

The evidence from both the surveys to multinationals and econometric studies therefore seems to suggest that the knowledge base, in particular that of universities, human capital and intellectual

[44] The authors classify reforms that expand and/or strengthen IPR along five dimensions: expansion in the range of goods eligible for patent protection; expansion in the effective scope of patent protection; increase in the length of patent protection; improvement in the enforcement of patent rights and improvement in the administration of the patent system.

[45] The authors conduct their main analysis on a sample of 16 host countries: Argentina, Brazil, Chile, China, Colombia, Indonesia, Japan, Mexico, Philippines, Portugal, South Korea, Spain, Taiwan, Thailand, Turkey and Venezuela; i.e., mainly developing countries.

[46] This result is in line with the Duranton and Puga (2005) result that activities belonging to the same function but not to the same sector are agglomerating together. While in the manufacturing/production sector the same is true for activities in the same sector.

property protection are important factors in the decision to locate investment in Research in a particular country. Development projects are also affected by access to local markets and by co-location with production activities. Tax breaks do not seem to affect the decision to locate R&D in a developing country while there is some variability in the importance of tax breaks and direct support to innovation for the location of R&D in developed countries.

Tax incentives and location of R&D

We discussed some survey evidence on the relevance of tax incentives and direct support to innovation for the location of R&D (Thursby and Thursby, 2006). However, the econometric evidence on the role of tax incentives on the location of R&D is still scarce. Most of the research on the effects of fiscal incentives has focused on taxes and corporate taxes in general rather than specific incentives for R&D activities. We will therefore first discuss the theoretical predictions and the evidence from this literature. We will then focus on the results on R&D tax incentives and R&D location, discussing both the descriptive evidence from qualitative data and econometric results from analysis of quantitative data.

Tax incentives and the location of multinational activities: the theoretical predictions

In standard models of tax competition (see survey by Wilson, 1999) mobile investment would be attracted in regions with lower corporate taxes. The rationale behind these models is that firms will, *ceteris paribus*, move to the country with the lowest tax rate. This in turn would give rise to a race to the bottom in corporate tax rates. On the other hand, the "New economic geography" literature predicts that a race to the bottom would not necessarily take place in the presence of agglomeration externalities (e.g. Ludema & Wooton, 2000; Baldwin & Krugman, 2004).[47] The reason is that these agglomeration economies will lead firms to locate or remain in locations even if they could be mobile and benefit from lower tax rates in other regions. Therefore differentials in tax rates can persist in the presence of agglomeration externalities. In fact Baldwin and Krugman show that the existence of agglomeration rents allows similarly sized nations to have different equilibrium tax-rates, contrary to the standard theoretical propositions in international tax competition. In fact they find that, with sufficiently free trade, industry can agglomerate in one country which can raise his capital taxes without losing capital because of agglomeration economies. This might lead to a 'race to the top' rather than a 'race to the bottom'.[48] In fact, Baldwin and Krugman challenge the idea that failure to align (capital) taxation would result in a

[47] The literature often refers to "first nature" and "second-nature" agglomeration externalities. "First nature" agglomeration externalities are due to exogenously given characteristics of different sites; while "second nature" agglomeration derives from the actions of human beings.
[48] The Baldwin and Krugman (2004) model finds also that other predictions of the basic tax competition models are reversed. For example they find that trade costs matter as well as the mobility of capital. Their model also predicts that if agglomeration forces are strong enough and capital is internationally mobile there will be a positive (rather than a negative) correlation between capital –labour ratios and tax rates: more industrialised region will have higher tax rates, *ceteris paribus.* Finally the paper confirms the findings from the economic geography literature that the agglomeration effects are much stronger for intermediate trade costs leading to a bell shaped relationship between taxes (agglomeration) and trade integration.

'race to the bottom' amongst countries in order to attract producers by competing in offering the lowest taxes. The inclusion of agglomeration forces in the analysis leads to conclusions far subtler than a simple 'race to the bottom': countries with generous welfare states paid for by high tax rates tend to be richer countries ("core countries") that relative to the poorer ("periphery") countries offer capital advantages (e.g. good infrastructure, established customer and supplier bases, skilled workforce) which allow them to attract and hold on to mobile factors of production even if they levy higher tax rates than poorer countries (up to a certain upper limit in the gap beyond which irreversible delocation takes place) leading to a race to the top in taxes before leading to a race to the bottom.[49]

Tax incentives and the location of multinational activities: the empirical framework

The empirical analysis of the effects of tax incentives on the location of multinational activities has been constrained by the availability of suitable microdata that contained information on both the cross-country location of multinational corporations and details about tax regimes across different countries.

The evidence from the literature on tax incentives[50] has analysed both the effects of taxation on the location of capital by multinationals and on the location of the income from that capital. This distinction is also important when we think about location of R&D activities: firms need to decide where to locate R&D investment and where to locate the income (e.g. patents; royalties) from those investments. The latter is likely to be affected by differences in statutory tax rates. Concerning the former location decision on investment, an important further distinction is between the decision of multinational on whether to invest in one country (extensive margin) and the decision on the scale of the investment, conditional on being located there (intensive margin). The literature on tax incentives suggests that these two margins are affected by taxes differently: the extensive margin is a discrete choice which is affected by the proportion of pre-tax income that is taken in tax, i.e. the effective average tax rate[51] (see Devereux and Griffith, 1998 for an example); while the intensive margin is a marginal decision and is affected by taxes through the cost of capital and therefore by the effective marginal tax rate. We believe that this distinction has important implications for the discussion of the effect of R&D tax incentives on the location of R&D investment and the design of R&D tax incentives.

An indication that distinguishing between location of capital and location of income from capital is important especially when looking at R&D activities can be found in the study of Stoewhase (2002). The study investigates the impact of statutory tax rate and effective average tax rate on the number of German multinational affiliates across eight countries. The author finds that while location of affiliates in production sectors is affected by the effective average tax rate;[52] the location of affiliates in the service, finance and R&D sectors are affected more by the statutory

[49] Moreover, since agglomeration is a bell-shaped function of the level of trade integration, the tax gap is also related to trade integration in a bell-shaped curve.
[50] For a comprehensive review of this literature we refer the interested reader to Devereux and Maffini (2007).
[51] One common measure of average tax rate at the firm level is the ratio of tax charges in the financial accounts on profits.
[52] The effective tax rate measures the tax burden of investment by dividing taxes paid by pre-tax profits.

tax rate, and suggests that this might be due to the fact that income from these activities may be more easily shifted to low-tax countries. These results are confirmed in other papers (e.g. Grubert and Slemrod, 1998 and Desai et al, 2006) that show that R&D intensive multinationals are more likely to be affected by the possibility of profit shifting and by the presence of tax havens (e.g. Puerto Rico in the late 80s).

To summarise, existing surveys of the literature (De Mooij and Ederveen, 2003 and Devereux and Maffini, 2007) suggest that taxation affects multinational decisions to locate their activities in a country, the intensity of this investment and the location of the income derived from this investment. However, the impact of taxes is heterogeneous, not only across different tax margins, but also across different sectors, activities and firms' and investments' characteristics. For this reason, it is important to have access to detailed micro-level panel data and it is also important to find good econometric strategies to identify the causal impact of taxation on location decisions by multinationals rather than just uncovering correlations. However, there are still very few papers that have been successful in this second endeavour and this is where the literature on the impact of taxation and location of multinational activities is still evolving.

Tax incentives are not the only tool that governments can use to attract foreign direct investment. A frequently used tool is grants/subsidies to set up greenfield plants in the host country. Examples of such grants/subsidies can be found across many countries. Case studies and econometric analysis of the successfulness of these policy tools are however not pervasive. An example of such a study is the work of Devereux, Griffith and Simpson (2007) who analyse the effectiveness of government grants in attracting foreign direct investment in disadvantaged regions of the UK. The authors find that incentives are more effective in attracting greenfield investments in regions with high agglomeration economies than to peripheral disadvantaged locations. Other papers have looked at the impact of European policies, rather than single governments' policies. For example, a recent paper by Basile, Castellani and Zanfei (2008) using data on more than 5000 foreign subsidiaries established in 50 regions of 8 EU countries over the nineties find that eligibility to European Structural funds (Objective 1 funds) does not make EU regions more attractive for multinational investment. However both the amount of EU Social funds and the eligibility of regions within countries to Cohesion Funds are strongly related to location of MNEs investment in the region. Therefore, in line with the evidence of the impact of taxes, the impact of grants and subsidies is also heterogeneous, across different programmes, different firms and regions' characteristics. Studies on the impact of programmes and subsidies are also still scarce and few use identification strategies that help them identify the causal impact of the subsidies on the location decision.

Cross-country studies on tax incentives and location of R&D activities

Few studies have analysed this issue across countries (Hines, 1995 and Hines and Jaffe, 2000; Bloom and Griffith, 2001) while others have looked at the impact of differences in R&D fiscal incentives across US states (Wilson, 2008).

Hines (1995) analyses aggregated data on R&D activities of US and foreign multinationals to show that the innovative activities in the host country are substitute for the innovative activity conducted in the home country

Billings (2003) uses macroeconomic data and analysis of variance to show that the growth rate of R&D of US foreign affiliates was higher in countries with tax-based R&D incentives than in countries that did not offer any tax-based R&D incentives. This is particularly the case for Japan, Mexico, Ireland and Brazil. These results are robust to exclusion of outliers and changes in US industry classification. One limitation of Billings' study is the use of aggregate data on US foreign affiliates, rather than company level data.

Jaffe and Hines (2000) use Compustat information on company R&D expenditure and match it with information on their patenting activity from the NBER patent database. Jaffe and Hines look at the interaction of taxation on three types of R&D and on foreign royalties on the innovative output of the firm. In particular they focus on the changes in US fiscal legislation in 1986 on the treatment of R&D conducted domestically for overseas sales; R&D conducted abroad and R&D conducted at home for domestic sales; and finally tax treatment of royalties on the innovation outcome abroad and in the US. The key tool for identification in the paper is that there will be a heterogeneous response to such changes by firms depending on their tax position relative to excess or deficit of foreign tax credits. The authors conduct an OLS regression of the difference in number of foreign patents in 1988-1991 relative to 1983-1986 on the change in number of domestic patents in the same period; the fraction of R&D expenses that the firm can deduct against their domestic tax liabilities in 1991; the percent of foreign sales and the change in the required cost of capital for a $1 dollar investment in domestic R&D intended to enhance foreign profitability. In robustness checks they also include the interaction of these two latter variables with the number of foreign patents in the initial period 1983-1986. The results show that those firms, for which the after-tax cost of doing domestic R&D for foreign sales grew most quickly after the 1986 change, also show the slowest growth of foreign patenting in 1988-1991 with an estimated cross-price elasticity of foreign patenting relative to costs of domestic R&D for foreign sales between 0.2 and 0.5. The authors highlight that these results suggest the existence of a complementarity between domestic and foreign innovative activity at the (multinational) firm level, but that they are not in contrast with evidence suggesting substitutability between domestic and foreign innovative activities at a more aggregated macro level, such as the ones presented in Hines, 1995 and in Bloom and Griffith, 2001 as described below.

Bloom and Griffith (2001) study aims at answering the question on whether the increased use of tax incentives is leading to an increase in R&D conducted worldwide (since the user cost of R&D is decreasing "globally"), or rather whether R&D tax incentives represent a form of tax competition between countries for 'footloose' R&D leading just to relocation of R&D activities. To answer this question they test whether the volume of R&D conducted in one country responds to changes in the R&D price in competitor countries using panel data for eight countries over the period 1979-1997 drawn from the OECD ANBERD database. The R&D price in competitor countries is measured as the weighted average of the user cost of R&D with weights depending on the amount of FDI investment going to each country during 1982-92.[53] Bloom and Griffith are also concerned about possible omitted variable that could affect both the user cost of capital and R&D. Therefore, they use the tax component of the user cost of R&D as instrumental variable. The results suggest that domestic R&D is a decreasing function of the domestic user cost of R&D and an increasing function of the foreign user cost of R&D.[54] They interpret this result as suggestive that domestic R&D and foreign R&D are substitutes and of relocation in response to R&D tax incentives.

The studies presented in this section show that still little is known about the importance of tax incentives for the location of R&D; especially there is only limited evidence on the impact of R&D tax incentive on cross-country location of R&D activities. Therefore, questions on whether (the introduction of) R&D tax incentives can *cause* the location of R&D investment in a country/ region or which design of the tax incentives is better for achieving such a policy goal cannot be answered. As we repeatedly mentioned, in order to answer such question one would need both detailed microdata and a credible identification strategy (based for example on exogenous eligibility criteria and their changes or randomizations) for the causal effects of the policy.

Within country studies on tax incentives and location of R&D activities

Within the US, Wilson (2008) using firm level data for the US show that availability of R&D fiscal incentives in US states is associated with relocation of firms towards States with more generous R&D fiscal incentive schemes. Using panel data over 1981-2004 Wilson estimates an augment R&D factor demand model and finds that the in-state elasticity of R&D spending relative to in-state user cost of R&D is -2.5 and relative to the out-of-state user cost of R&D in neighbouring states is +2.7, and therefore he derives a net effect at the national level that is near zero.

Neither the Bloom and Griffith (2001) study nor the Wilson (2008) study analyse whether firms are shifting existing R&D activities towards more favourable areas in terms of fiscal incentives, i.e. the policy has an effect on their “intensive margins” (how much R&D to do in each area) or whether they are locating new R&D activities in one area and shutting down existing labs in the areas with the least advantageous fiscal regime; i.e. whether the policy has an effect on the “extensive margin” (i.e. whether to do R&D or not).

In fact, neither Bloom and Griffith nor Wilson studies have the necessary microlevel (establishment/firm) data to look at the difference between the impact of tax incentives on intensive and extensive margins.

Microlevel data would provide the additional advantage of describing the heterogeneity of the effects of R&D tax incentives on different types of firms (high vs low R&D spenders; start-up vs mature businesses). Additional evidence on the design and the eligibility rules of the policy and

[53] The main advantage of using weights based on FDI is that in most countries firms can benefits from R&D tax credits if they have taxable profits in that country.
[54] This result is stronger when using a static model relative to a dynamic one.

on how it changed over time would provide the possible source of identification of the causal impact of the policy. Finally, if data were available not only on tax incentives but also on other innovation policies (e.g. strength of IPR, policies for public research and universities) then one could investigate whether these policies are complementary to each other or whether they are substitute.

Policy Conclusions

Tax incentives might affect investment location of MNEs; however, there are other factors that affect the investment decisions of firms. In particular survey based and econometric evidence suggests that the presence of a market and of other (multinational) firms; universities; a skilled workforce and strong intellectual property rights seem to be important determinants of location of R&D activities.

Governments with a tight budget constraint therefore might face a trade off: should they allocate their limited resources to provide fiscal incentives for firms to locate their R&D activities and lose tax revenues or should they try to maintain the level of tax revenues that would allow funding of universities; skills and infrastructure that would make the region/country attractive to foreign investors?

Also, will countries race to the top or race to the bottom? The new economic geography literature seems to suggest that a race to the top is possible especially within the European Union. At the same time, the few empirical studies Bloom and Griffith, 2001 and Wilson, 2008) that estimate the elasticity of R&D to R&D costs at home and abroad – at the national and regional level - seem to suggest that while a decrease in the costs of R&D at home is associated with an increase in the level of R&D, a decrease in the cost of R&D abroad (e.g the introduction of an R&D tax credit) is associated with a decrease of R&D activity at home. In fact Wilson estimates suggest that - within the US - setting of R&D tax credits by states is nearly a zero sum game. How transferable to the European policy context this result is remains debatable. It is likely that the cross-country effect might be smaller in the EU where the cross-(member) states mobility is lower than in the United States. However, this might change as the degree of geographic mobility in R&D activity increases within the EU.

Finally, there are other features of the tax system that might lower the fiscal burden on firms. In particular, countries should make sure that the compliance costs are low; the fiscal system is clear and stable. These are factors that seem to be taken into account by firms when evaluating different fiscal systems.

The question, however, remains on how government can evaluate the successfulness of their R&D tax incentive policies in affecting the location of R&D. The key ingredients of such evaluations are (1) availability and access to rich longitudinal microlevel firm and establishment data both across countries and within countries (2) the use of robust identification strategies. Both of these elements are essential for the understanding the causal impact of R&D tax incentives on both the decision to invest in R&D in a particular country and the amount of that investment. In an ideal world, one would want to be able to observe choices of multinationals when deciding where to locate their R&D labs; know the ranking of the locations (i.e. which country/region was the runner up?) and the whole functional structure of the multinational. In addition one would want to know other time-varying country characteristics and observe exogenous changes in the availability of R&D tax incentives. An alternative approach would be to randomize the availability of some incentives to some multinationals rather than others. Obviously this latter approach – although very appealing from the point of view of the econometrician to evaluate the policy – is very hard to implement in practice because of political reasons.

In this review, we have discussed the impact of tax incentives for R&D activities on the location of R&D investment. We have, however, not explicitly discussed a related question on whether the introduction of new (or the increased generosity of existing) R&D tax incentives in the home country affects the decision of existing R&D investment of whether to relocate abroad. This is a very interesting question which remains yet to be explored and it might be an interesting question for future research.

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Annex 2

Tax incentives for industry-science R&D collaboration

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Introduction

Successful creation of new knowledge often depends on the ability of firms to establish cooperative R&D agreements in order to combine their resources, exploit complementary know-how, and internalize R&D externalities (Katz, 1986; d'Aspremont and Jacquemin, 1988; Kamien et al., 1992).

Governments have long understood the virtues of R&D collaboration and have exempted R&D partnerships from anti-trust legislation. In the European Union, for instance, the Treaty of Rome already contained a notice in article 85(3) that collaborating in R&D is permissive as long as post-innovation rivalry is not blocked. In 1984, the European Commission approved a block exemption for R&D collaborations that also allows joint exploitation of results (see Martin, 1997 for an overview on policy practices in the U.S., Japan and Europe).

In addition, governments often subsidize R&D collaborations. Governments of European Member States maintain subsidy schemes, where grant applications from consortia are preferred over single firm applications. In the recent past, technology transfer from science to industry has attracted the attention of policy makers, and as a result industry-science collaborations are often granted a preferential treatment in public grant systems. It is believed that an enhanced knowledge and technology transfer from science to industry also contributes to the long-run innovativeness and thus competitiveness of the business sector.

The potential benefits of R&D collaborations can be summarized as follows: First, technological spillovers are internalized, thus eliminating the free rider problem within the group of cooperating firms. Second, since R&D often exhibits economies of scale, it might well be that only a consortium of firms has the necessary resources both financially and physically to undertake the ever larger, more complex, and more expensive research projects that are common today. Third, economies of scope also often characterize the R&D process. Hence, synergetic effects and risk pooling can broaden the research horizon of cooperating firms. It can thus be expected that sustaining R&D cooperatives leads to an increase in private R&D activity. Formal economic models show, indeed, that under certain circumstances R&D cooperatives devote more resources to innovative activities than competing firms would. From the ever growing literature on cooperative R&D can be concluded that cooperative R&D levels exceed non-cooperative levels whenever technological spillovers are large, while the opposite holds for small technological spillovers (see Veugelers 1998 for a survey of theoretical and empirical literature).

This paper discusses the potential impacts of R&D tax credits schemes involving higher tax allowances for firms that collaborate with public research institutions when compared to other tax credit recipients. First, the market failure for R&D and the economics of R&D collaborations are discussed where both theoretical and empirical literature is reviewed. Second, recent literature on effects of R&D policies at the firm level is briefly discussed. The third goal of the paper is the combination of both strands of literature which leads to suggestions on how current R&D tax schemes involving extra tax deductions for companies engaging in industry-science collaborations should be evaluated in European Member States.

Theory

The market failure for R&D investment

The standard argument for governmental intervention in the market for R&D is based on two market failure arguments. First, R&D creates positive, external effects, that is, R&D creates knowledge and as Arrow (1962) hypothesized, something intangible such as knowledge cannot be kept secret to full extent by the original R&D investor. This implies that a private company investing in R&D will not be able to appropriate all returns from its initial investment as knowledge will spill over to rivals and other third parties that subsequently free-ride, i.e. build on the knowledge, without having participated in the investment. This may happen due to the mobility of personnel, but also through many other channels, e.g. joint customers or suppliers (see e.g. Mansfield, 1985). Thus the social benefit of R&D investments is typically much larger than the private return. As, however, firms will only decide on investments with a positive expected private return, many R&D projects that are socially desirable may not be undertaken. This leads to a gap between social and private equilibrium and, consequently, a justification for governmental intervention.

The second market failure argument is typically established due to financing constraints for R&D. If a firm seeks external financial resources for an investment, R&D features several characteristics that make it more difficult or expensive to finance externally than, for instance, investment in tangible assets. For instance, the lion’s share of an R&D investment project is sunk cost, as R&D mainly consists of wages for researchers. In contrast to physical capital investment, R&D is not capitalized in the balance sheet of a firm, so that it cannot be used a collateral in credit negotiations with banks. Furthermore, the outcome of an R&D project is typically much more uncertain than the return of investments into physical capital which makes potential lenders also less likely to invest. See e.g. Hall (2002) and Hall and Lerner (2010) for surveys of this strand of literature, or the summary paper on financial constraints for R&D in this report (Annex 3).

Although these are good economic reasons for governments to finance R&D publicly, i.e. financing R&D in universities, and also in form of grants or tax credits to the private companies, it is not straightforward to establish a clear-cut theoretical market failure argument for a preferential treatment of industry-science collaborations within certain schemes. Exempting R&D collaboration from anti-trust legislation can already be seen a policy itself, as the possibility of collaborating in R&D allows firms a) to internalize the potential external effects at least within the consortium of project partners, b) spreads the risk of outcome uncertainty and c) divides the cost of R&D among involved agents.

However, in combination with some empirical evidence from the literature on knowledge and technology transfer between science and industry, arguments for such extra incentives may be made.

As will be outlined below, it seems to be a generally accepted opinion that involvement of universities or other public research institutions concerns more basic research projects and the transfer of more generic knowledge than the “usual” business R&D projects. The idea is that companies seek university collaboration for more fundamental, long-term and possibly strategic R&D projects. Empirical evidence supports this view. Thus, is could be argued that R&D conducted within industry-science collaborations involves projects that are socially more desirable than others, as more basic knowledge is created which expectedly would lead to higher knowledge spillovers, i.e. the social return to these investments is high. From the companies’ perspective, however, basic research suffers from worse appropriability conditions than other projects. For instance, without any specific industrial application in mind, the original investor may not be able to take out a patent for protecting the results of the initial investment. In addition, the uncertainty about expected pay-offs of such investments is typically even higher than for other R&D investments, as projects of more basic research are further away from the market and its potential applicability to new products and processes may be largely unknown at time of the investment. This reasoning leads to the conclusion that the market failures due to external effects and financial constraints apply even more for research conducted within industry-science consortia than for other projects making a higher degree of governmental intervention than for other R&D justifiable.

Theory of R&D collaboration

This subsection reviews the theoretical literature on R&D collaboration. The industrial organization literature makes a clear distinction between horizontal collaborations, i.e. among firms in the same industry, versus vertical or diagonal collaboration, i.e. firms in vertically related or non-related industries. As the understanding of mechanisms in horizontal collaborations is key to the other model approaches, the literature on horizontal collaboration is discussed first.

Horizontal R&D collaboration

The question of how and why firms engage in R&D collaborations and how that affects welfare emerged during the 1980s in economic literature (see Veugelers, 1998, for a survey). The industrial organization literature emphasizes the importance of knowledge spillovers in the context of collaborative research (e.g. Katz, 1986, d'Aspremont and Jacquemin, 1988, Beath et al., 1988, De Bondt and Veugelers, 1991, Kamien et al., 1992, Motta, 1992, Suzumura, 1992, Vonortas, 1994, and Leahy and Neary, 1997). Such studies relate decisions to collaborate in R&D to the presence of spillovers and the effects on market performance with respect to profits. Models rely on the fact that returns from R&D are not fully appropriable by the firm, but knowledge leaks out to competitors such that social benefit is higher than private return. This, of course, leads to underinvestment in innovative activity from a social point of view. R&D collaborations are one possibility to internalize such knowledge spillovers and thus increase appropriability of returns within the research consortia. Three main issues with respect to cooperative R&D are considered in the following: coordination, free-riding and information sharing.

Coordination in such models is typically described through joint profit maximization. One finding is that investment in R&D among collaborators increases with the level of spill-over effects. A second result states that if spillovers are high enough, that is, above some critical level, cooperating in R&D will result in higher investment compared to the status of no collaboration (cf. De Bondt and Veugelers, 1991). Cooperating in R&D always increases firms' profitability. Consequently, when spillovers are high enough, firms have an increasing incentive to engage in R&D collaborations, and this should enhance welfare. It should be noted, however, that cost of coordinating R&D is often ignored in these models.

Collaborations bear the inherent risk of free-riding that may distort the stability of cooperation. Partners may free-ride as they could try to absorb knowledge from their partners but conceal their own (see e.g. Shapiro and Willig, 1990, Baumol, 1993, Kesteloot and Veugelers, 1994). Models find that cooperative agreements for being profitable and stable require that involuntarily outgoing spillovers are not too high. This is in contrast with the results on coordination, where profits are higher with larger spillovers. Here the profitability of collaboration increases with the firms' ability to manage the outgoing spillovers in order to protect against possible free-riding of partners.

Some models explicitly account for information sharing among partners that is managing spillovers (e.g. Kamien et al., 1992, Katsoulacos and Ulph, 1998). Katsoulacos and Ulph model the choice of spillovers and find the research joint ventures will always share at least as much information as non-cooperating firms, because research joint ventures maximize joint profits. Another issue for managing spillovers is absorptive capacity. Cohen and Levinthal (1989) point out that incoming spillovers can be used more efficiently (in reducing own cost) when the firm is engaged in own R&D. Engaging in own R&D builds absorptive capacity, that is, the ability of a firm to benefit from the knowledge of others created through R&D activity. Kamien and Zang (2000) take that into account, and find ambiguous results with respect to R&D investment. Yet, collaboration is still the more profitable option.

In conclusion, theory states that non-collaborative R&D levels decrease with magnitude of spillovers, while cooperative investments tend to increase with spillovers, and thus imperfect appropriability of knowledge generating processes increases the benefits from collaborative agreements. If spillovers are above a certain level, the "critical spill-over", co-operative R&D will result in higher investment than non-cooperative R&D. The presence of spillovers increases the incentive for R&D collaboration through the internalization of the positive externality. Kamien and Zang (2000) show that result may no longer hold when absorptive capacity is taken into account, though. Information sharing increases the profitability of R&D cooperation. When spillovers are high enough, collaborating firms will not only invest more in R&D, but are also more profitable than independently researching firms. Welfare is enhanced when spillovers are large enough, but ambiguous when spillovers are low. However, imperfect appropriability also encourages free-riding on R&D performed by other firm.

Theoretical results have initiated a whole debate on the implications of R&D collaborations for antitrust and the treatment of research joint ventures, leaving a favourable policy stance towards this type of cooperation (Ordover and Willig, 1985, Jacquemin, 1988, Shapiro and Willig, 1990). Although it seems to be an important policy conclusion leading to a more lenient policies towards R&D collaborations, it should be stressed that this only holds for co-operation restricted to R&D. If R&D collaboration would facilitate product market collusion, the welfare enhancing results do no longer hold, of course. Hinloopen (2001) is one of the few papers that explicitly model the impacts of subsidies on collaborative and non-collaborative R&D.[55] The policy towards collaboration is not a subsidy, but only the legal opportunity to engage in R&D collaborations. Given this framework, he finds that the incentive to invest in R&D is higher for subsidies than the policy of allowing for collaboration. In a further step, Hinloopen shows that in case of optimally subsidizing cooperative or non-cooperative R&D leads to the same level of R&D activity. This suggests that "[...] sustaining R&D collaboratives is a redundant industrial policy, all else equal." (Hinloopen, 2001: 316)

Vertical and diagonal R&D collaboration

The vast majority of theoretical models deals only with horizontal R&D co-operation, that is, collaboration among competitors, as the joint choice of R&D in combination with product market competition sets an interesting framework for theoretical modelling towards the drivers of such decisions. While this set-up is predominant in theory, it stands in stark contrast to empirical evidence (mostly from surveys such as the Community Innovation Surveys and similar sources): typically, firms' most important collaboration partners are customers, suppliers and universities or other research institutions. Empirically, collaboration with competitors is not found to be a significant case in most countries, at least in terms of frequency of collaborations.

However, the theoretical literature on vertical collaboration including industry-science cooperation is scarce. The reason is that vertical collaboration partners do not impose a negative externality on each other, as they do not compete in the same product market. Thus, the

[55] See also Hinloopen (1997, 2000a, 2000b).

theoretical concerns concerning the trade-offs in cost and benefits of R&D collaborations apply to a lesser extent to vertical collaboration. Firms may engage in vertical R&D collaboration to reduce the cost of R&D, e.g. a firm decides to collaborate with a university as the public research institution may possess “superior” knowledge for certain projects than the firm has internally available. Rather than generating this knowledge in-house, it may be preferable to seek it externally. Furthermore, seeking complementary knowledge may lead to economies of scale and scope which in turn result in increased in-house R&D (see Cassiman and Veugelers, 2006). Similarly to horizontal collaboration, risk sharing arguments concerning the outcome uncertainty of R&D investments are a further motive for engaging in vertical collaboration. Firms would choose to engage in vertical collaboration if the expected benefits outweigh the transaction cost involved. Steurs (1995) is the first paper that extends models of R&D collaboration to inter-industry spillovers. While typical collaboration literature considered only horizontal collaboration, this study analyzes a two-industry, two-firm-per-industry setting. It is assumed that intra-industry and inter-industry spillovers exist. As firms engaging in inter-industry collaboration do not impose a negative externality on each other, it is found that inter-industry collaboration is socially more beneficial than cooperatives whose members come from a single industry. In the Steurs (1995) model, the industries are not related except for the presence of spillovers. This framework is extended by Inkmann (1999) who explicitly models strategic R&D investment in the presence if R&D spillovers between vertically related industries. The R&D investments of the upstream firm affect the production process or quality in the downstream firm which in turn leads to higher demand in the final product market and thus also for the intermediate good. In equilibrium, vertical collaboration maximizes the profits of the participating firms, and leads to increased R&D in the economy. A similar model is presented in Atallah (2000) where vertical R&D collaboration unambiguously leads to higher R&D and welfare in the economy. These papers are able to explain the empirical finding that vertical collaborations are much more frequent than horizontal collaborations in reality.

The inter-industry collaboration as referred to in the Steurs (1995) study can be interpreted as industry-science collaboration. Although the paper labels the agents as two firms in non-related industries, the term “firm” could be replaced by university, as the two agents are neither related horizontally nor vertically in any market. There are simply knowledge spillovers possible between them. This to a large extent applies to the relationship between a firm and a university within collaborative agreements. As these “diagonal” collaborations create a higher social welfare than other types of collaboration, it may be argued that it is desirable to foster the emergence of such consortia in reality. Consequently, we now review the empirical evidence on R&D collaboration. For reaching policy conclusions, it is necessary to find empirical support for the above mentioned theoretical effects.

Empirical Evidence

This section first reviews a selection of empirical studies on the determinants of collaboration with special attention to industry-science partnership and also reports some empirical evidence on the effects of these collaborations at the firm level. Afterwards, results of empirical studies on the evaluation of R&D policies are briefly introduced. These two components then lead to studies that analyzed both the effects of R&D policies and collaboration on firms' innovation activity.

Empirical studies on collaboration

Recent empirical studies have established that contractual forms of R&D, such as joint R&D, have become a very important mode of inter-firm and science-firm collaboration as the number of partnerships has largely increased (Sakakibara, 1997; Hagedoorn/Narula, 1996). Several empirical papers on R&D collaborations are reviewed in Veugelers (1998). As one recent example, Cassiman and Veugelers (2002) explored the effects of knowledge flows on R&D co-operation. Their results suggest that firms with higher incoming spillovers and better appropriation have a higher probability of co-operating in R&D which confirms the arguments on spillovers made by theoretical contributions.

Not many studies analyze industry-science collaborations explicitly. Hall et al. (2003) conducted a survey-based study of research projects having universities as research partners within the U.S. ATP program. They argue that universities are involved in such projects that apply "new science", i.e. firms seek for expertise to absorb results of basic research. The role of the university may be a translation of basic science towards an applicable technology for selected problems. This interpretation is supported by the fact that universities are engaged in industry collaboration in fields where business R&D is closer to science, particularly in areas where technology tends to be more complex. University involvement also occurs more frequently in projects that are broader in scope. Projects where results are expected in a timely manner for a specific technological problem are typically not conducted in collaboration with universities.

Cassiman and Veugelers (2005) explore the determinants of industry-science collaboration using Belgian Community Innovation Survey (CIS) data. They emphasize that there are large industry differences in the probability of a firm collaborating with science. Firms in the chemical and pharmaceutical industry are most likely to collaborate with universities. Furthermore, firms that are impeded by high cost of innovation are often attracted by government subsidized cost-sharing in public-private partnerships. In addition, larger firms are more likely to collaborate with universities than smaller firms indicating that some minimum absorptive capacity is needed for fruitful collaboration. In contrast, there is no evidence for the risk-sharing argument in industry-science collaborations, which the authors relate to potentially higher transaction cost when communicating with science. Similarly, Belderbos et al. (2004a) also analyze the determinants of university collaboration, but they also account for engaging in collaboration with different types of partners in a system of equations where they include a measure of incoming spillovers from these potential collaboration partners. Among others, one interesting finding is that spillovers received from universities not only stimulate industry-science partnerships but also R&D collaboration with other partners.

Belderbos et al. (2004b) investigate the impact of R&D collaboration on firm performance using panel data of Dutch manufacturing firms. The interesting feature of this study is the distinction of two dependent variables, growth of labour productivity and of firms' productivity in innovative sales, where the latter is measured as growth rate in sales of products that were market novelties.

It turns out that R&D collaborations with competitors and suppliers positively affect productivity growth. Belderbos et al. refer to this as result of incremental innovation leading to higher sales of established products. For market success of more radical innovation projects, however, university collaborations play an important role along with the cooperation with rivals. They also find that customers and universities serve as important sources for sales growth in market novelties in absence of formal collaborative agreements.

Empirical studies on R&D policy

The impact of R&D policies on firms' innovation behaviour has been of interest in the economic literature for decades. The predominant question investigated is whether public subsidies crowd-out private investment. David et al. (2000) survey microeconomic and macroeconomic studies on that topic. One result of their survey was that most estimations in the reviewed studies are subject to a potential selection bias as recipients of subsidies might be chosen by the government because they are the most promising candidates for successful research projects. In this case, public funding becomes endogenous to innovative activity and this has to be taken into account. More recent studies correcting for selection include, among others, Busom (2000), Wallsten (2000), Lach (2002), Czarnitzki/Fier (2002) and Almus and Czarnitzki (2003), Duguet (2004), Czarnitzki and Licht (2006), Gonzalez et al. (2006) and Hussinger (2008). Results are ambiguous: Busom finds positive effects of public funding on R&D in Spanish manufacturing, but cannot rule out partial crowding out for a subsample of firms. Wallsten finds full crowding out effects in the US SBIR program, an initiative to foster innovation in small and medium-sized US companies. Lach reports large positive effects for small firms in Israel's manufacturing, but no effects for large firms. The analysis of Czarnitzki and Fier rejects full crowding-out effects in German service industries. Almus and Czarnitzki analyze Eastern German manufacturing where the government offers a high amount of subsidies in order to enhance the transformation process from a planned economy to a market economy since the German reunification in 1990. They conclude that about 50% of R&D performed in Eastern Germany would not have been carried out in the absence of public innovation programs. Similarly, Czarnitzki and Licht (2006) compare firms in Western and Eastern Germany and also extend the treatment effects estimation to a second-step where the productivity of privately financed R&D and subsidized R&D is compared. They find that subsidized R&D is almost as productive with respect to patent output as other R&D. See Hussinger (2008) for a related result on new product sales. Duguet (2004) rejects crowding-out in R&D using a sample of French firms. Gonzalez et al. (2006) employ a large panel of Spanish manufacturing firms and find no evidence for crowding-out either.[56]

Studies combining collaboration and R&D policy

Just a few empirical analyses, however, deal with R&D co-operations as a part of firms' innovative behaviour *and* as a policy instrument. Among those, Sakakibara (2001) analyzed Japanese government-sponsored R&D consortia over 13 years and found evidence that the diversity of a consortium is associated with greater R&D expenditure by participating firms. The

[56] Fewer studies deal with public policies and general firm performance, such as employment or sales growth. See the survey by Klette et al., 2000, for examples of such studies.

results support the thesis that high spill-over effects occur. The magnitude of the effect of the participation in an R&D consortium on a firm's R&D expenditures is found to be 9%, on average. Branstetter and Sakakibara (2002) examine the impact of government-sponsored research consortia on the research productivity in Japan by measuring their patenting activities over time. They find evidence that participants of research consortia tend to increase their patenting after entering a consortium, which is interpreted as evidence for spillovers above the "critical level". The marginal increase of participants' patenting in targeted technologies, relative to the control firms, is large and statistically significant.

Czarnitzki and Fier (2003) employ econometric matching analysis to investigate whether R&D collaboration leads to higher patent outcome as a measure of intermediate innovative output. Controlling for R&D input, firm size, industry heterogeneity and other common covariates, they find that firms that collaborate achieve higher patent outcome than under no collaborative agreements. Using German data they also demonstrate that German R&D policy in the 1990s increasingly subsidized research consortia comprising of firm-firm partnerships or industry-science partnerships. Consequently, they also analyze whether firms that were engaged in a publicly funded research consortium innovate more in terms of patents than firms that engaged in collaboration on a privately financed basis. Czarnitzki and Fier find that firms in publicly-sponsored research consortia indeed file more patents than other collaborators. This can have several reasons, however, which could not be further disentangled. First, the higher output of patents can be due to the monetary value of the subsidy in the sense that R&D is increased as response to the receipt. However, it can also be the case that firms in publicly funded research consortia interact to a larger extent with universities or other public research institutions as such consortia were given preferential treatment by the funding agency. This would hint at higher spillovers in industry-science relationships.

Czarnitzki et al. (2007) employ a heterogeneous treatment effects estimator where R&D collaboration, R&D subsidies and the combination of both are considered as a treatment. Their analysis is conducted for Community Innovation Survey data from Germany and Finland. Although the two countries have similar frameworks for technology policy, it can be observed that the frequency of R&D collaborations is much higher in Finland than in Germany in the early 2000s. Czarnitzki et al. (2007) find that both R&D collaboration and public R&D grants result in higher R&D in the treated firms. Firms that receive subsidies and are engaged in R&D collaboration exhibit complementarities, that is, they invest more in R&D than any other group of firms, which amounts to the estimate of three counterfactual situations of investment under "only subsidy receipt", "only collaboration" or "neither subsidy receipt nor collaboration". This also points to the presence of sufficiently large spillovers in collaborative agreements, so that firms increase R&D input. Another interesting result of their study is the analysis of "treatment effects on the untreated". As said above, the level of R&D collaboration is high in Finland. The econometric estimations have shown that firms not engaged in collaboration would not invest more in the counterfactual situation of engaging in R&D collaboration. In Germany, however, where R&D collaboration is less frequent, Czarnitzki et al. found that firms would invest more in R&D if they would engage in collaboration, on average. Thus, the authors conclude that there would be additional room for fostering collaboration in German technology policy while in Finland this seems to be limited. The Finish population of non-collaborating firms is to a larger extent characterized by very small firms than in Germany. Such firms may not have the necessary absorptive capacity or capabilities to benefit from R&D collaborations.

Suggestions for Policy Evaluation

As of today, there is no single study that has analyzed the treatment effects of publicly subsidized collaboration with public research institutions within R&D tax credit schemes. This, however, appears to be a further step in the evaluation of current (European) policy practices. Several countries' R&D tax credit schemes include additional incentives for industry-science partnerships. For instance:

- Belgium maintains a withholding tax credit since 2005. Companies collaborating with a European university or with Belgian research institutes are entitled to keep 75% of the withholding tax the companies are supposed to pay for the researchers.

- In Denmark, companies undertaking R&D in-house are allowed a 100% deduction of R&D expenses. However, companies engaging in collaborative R&D with a university or public research institute are allowed a 150% deduction from taxable income.

- In Hungary, a 300% allowance from taxable income is granted. This incentive is offered in cases where the company maintains a laboratory at a university or public research institution.

- The Netherlands maintain an R&D wages tax credit scheme which takes the form of a reduction of the tax and social insurance contributions of the firm. It ranges from 14 % for large companies to 42% for small companies. However, the company does not need to carry out R&D in-house. As long as the R&D activities are performed on the basis of written collaborative agreement with other organizations which employ and pay wages to scientists and researchers, such as universities, the allowance is granted.

- Within the Norwegian SkatteFUNN scheme companies can deduct R&D cost of up to 5.5 million NOK. If R&D is conducted in collaboration with a university or qualifying research institution, this cap has been 8 million NOK. In 2008, it was increased to 11 million NOK for industry-science collaborations.

- In Spain, R&D expenditures on projects contracted with universities or other research organizations are given an extra tax credit of 10 per cent over the regular rate.

Given these incentives, evaluations of such schemes appear to be useful for countries considering an introduction of additional incentives for collaboration in their tax credit programs.

Evaluations of policy schemes can be conducted in various forms. Techniques range from quantitative, econometric studies, qualitative assessments to in-depth case studies of selected companies. Econometric studies require availability of large scale databases at the firm level. If, however, such data is easily available, cross-country evaluations can be conducted at relatively low cost. Qualitative analyzes and in-depth case studies typically focus on some selected firms and can deliver more details than econometric studies. Disadvantages, however, are typically high cost of comparable cross-country studies as such evaluations may involve extensive interviews with awardees, and also the generalization of results from selected cases to the population of awardees.

As empirical evidence on R&D tax incentives for collaboration with research institutions is currently non-existent, it is recommended to conduct an econometric evaluation study as a first step. The first question that should be investigated is whether program awardees react with increased R&D to the collaborative research subsidy. This could also shed light on the existence of sufficient knowledge spillovers among collaborating parties. In a further step, innovation output measures could be taken into consideration. A quantitative analysis for this special case has the advantage that the necessary data should have been collected by the program administration to a large extent and that studies for different countries may deliver robust evidence on the policies' success. The following paragraphs recommend some possible set-ups for econometric evaluation studies.

An econometric evaluation of R&D tax credit programs typically requires panel data where subsidy recipients' variables of interest had to be observed over time. In addition, policy changes (e.g. in the allowed rate of tax deduction) had to be observed (see e.g. Hall and van Reenen, 2000). As R&D tax credits typically apply to all R&D performers in an economy, control group approaches where subsidy recipients are compared with non-recipients are not applicable. Although it is well known that not all eligible companies in fact apply for R&D tax credits, the reasons for this behavior are not generally known and this questions the validity of such firms as control observations for the purpose of comparison. Consequently, researchers typically exploit panel data including policy changes. If the policy is not subject to crowding out effects, an increase in the allowed tax reduction should coincide with an observed increase in R&D spending of tax credit recipients over time, and vice versa (see e.g. Hall et al., 2005). So far, evidence suggests that typically each dollar of tax allowance leads to a dollar change in companies' R&D roughly.

Designing econometric evaluations

The parameter of interest on most common policy evaluations is the so-called "treatment effect on the treated" (*TT*). The standard evaluation question when a subsidy scheme is evaluated compares the observed innovation activity to a counterfactual situation when the policy under review is hypothetically absent. Then, the question of interest becomes "How much would a firm that has received a subsidy have spent on R&D activities if it would not have been subsidized?":

$$\gamma_{TT} = E\left(Y^T \middle| S=1\right) - E\left(Y^C \middle| S=1\right), \qquad (1)$$

where Y^T refers to the potential outcome (e.g. R&D expenditure) of firms that receive subsidies, and Y^C to the situation where they do not. *S* indicates the treatment status. It is equal to 1 for treated firms and zero otherwise. Thus, the *TT* results from comparing the actual outcome of subsidized firms with their outcome in case of not receiving a grant which is not directly observable and therefore often referred to counterfactual or potential outcome.

The approach of measuring potential outcomes goes back to Roy (1951). The outcome $E\left(Y^T \middle| S=1\right)$ can be estimated by the sample mean of *Y* in the group of subsidized firms. In order to identify $E\left(Y^C \middle| S=1\right)$ one needs to make further assumptions. The latter cannot simply be calculated from non-subsidized firms as

$$E\left(Y^C \middle| S=1\right) \neq E\left(Y^C \middle| S=0\right) \tag{2}$$

due to non-random assigned treatments. This would only be valid in an experimental setting where subsidies are granted randomly to firms, which is obviously not the case in current innovation policy practice.

The econometric literature offers a variety of methods for estimating $E\left(Y^C \middle| S=1\right)$. Commonly used are matching methods, parametric treatment effect models, instrumental variable techniques and (conditional) difference-in-difference estimation if panel data is available (see e.g. surveys by Heckman et al., 1999, or Imbens and Wooldridge, 2009). The applicability of these methods depends to a large extent on data availability, but all make use of control groups in one or the other form. The next section discusses a possible outline for an evaluation of R&D tax credit schemes for industry-science collaboration.

Panel data and introduction of an industry-science bonus

Suppose one is interested in the question whether the introduction of an extra tax credit for industry-science collaborations results in higher levels of R&D spending at the firm level. Consider two periods. Assume that R&D of tax credit recipients is observed in t_0 and t_1, but the bonus for industry-science collaboration is only introduced in t_1 (and assume that all firms actually engaging with universities also claim the extra tax credit). The "treated" firms are those that receive the extra bonus in t_1. An intuitive approach for estimating the counterfactual situation is based on observing R&D of these firms in t_0 in absence of the policy. Thus simply comparing R&D of the "treated" firms in t_1 and t_0 would give an indication of the treatment effect ("before-after" estimation). However, the change in R&D over time can also be influenced by macroeconomic shocks. Therefore, the change in R&D of treated firms over time can be compared to a control group of R&D performers that do not claim the new collaboration tax credit in t_1. If one is prepared to assume that macroeconomic shocks hit all tax credit recipients in similar way, this estimator would control for changes in R&D levels over time (difference-in-difference estimation).

In a standard panel data model setting, one would, in a sample of tax credit recipients, regress R&D on a dummy that is equal to one in period t_1 if the firm claimed the extra bonus for interacting with science (and zero otherwise), and other appropriate control variables (e.g. firm size and other measures commonly used in such studies) including firm-fixed effects. In such setting, one would expect a positive and significant coefficient of the industry-science dummy. In terms of an equation, it may be written as

$$R\&D_{it} = c_i + \beta x'_{it} + \gamma T_{it} + \delta t + e_{it} \qquad \text{with } i = 1,\ldots N, \text{ and } t = 0,1,$$

where c_i denotes a firm-specific intercept, x a vector of firm characteristics and T represents the treatment dummy, i.e. the fact that the firm claimed the extra industry-science collaboration tax credit, and β, γ, and δ are coefficients to be estimated. The treatment effect would be γ.

A positive sign of γ can, however, result from two different sources in the special case of evaluating the policy for industry-science collaboration. In t_0 some firms may have already collaborated with universities in absence of the extra tax credit for industry-science collaboration, and others may not have done so, but decided to start collaborating as a response to the new policy incentive. Thus, as outlined above the coefficient of the dummy variable would comprise two different effects: the pure “money” effect of the subsidy making R&D relatively cheaper compared to other factor inputs in production, and the “spillover” effect because of engaging in industry-science collaboration. In an appropriate evaluation of the policy it would be interesting to disentangle these two effects. Consequently, it would be desirable to observe the fact of “industry-science collaboration” in both periods t_0 and t_1. Then one would distinguish three groups of firms within the tax credit recipients: a) those firms that collaborated with science in t_0 and t_1 and claim the extra collaboration R&D tax credit in t_1; b) firms that did not collaborate in t_0, but did so in t_1 and claim the extra tax credit; and c) firms that did not collaborate in any of the periods and just received the standard tax credit on both periods.

Consequently the equation would change to:

$$R\&D_{it} = c_i + \beta x'_{it} + \gamma^{(a)} T_{it}^{(a)} + \gamma^{(b)} T_{it}^{(b)} + \delta t + e_{it}\,.$$

The estimated coefficient of the dummy variable indicating the group (a) will now reflect the pure “money” effect of the subsidy, as the status of industry-science collaboration did not change between the two periods for these firms. The estimated coefficient of the dummy variable labeling group (b) should be expected to be larger than that of group (a) as this includes both a money effect and a spillover effect. Consequently, one should subtract the coefficient of the (a) dummy from the (b) dummy in order to get an estimate for the spillover effect. The group of firms that only received the standard tax credit should be included as control group as R&D may change over time due to common macro economic shocks. This allows estimating the coefficient δ, the effect of a common macroeconomic shock from period 0 to 1, independently of the treatment dummies.

If one believes that the R&D tax credit recipients in group (c) differ substantially from those in groups (a) and (b) one may cast doubt on the assumption that the (c) firms respond similarly to a macroeconomic shock. In that case, one could only include firms of the (c) group that are similar in their characteristics *x* in t_0, that is, one would "match" the firms in (a) and (b) to firms in (c) conditional on *x*. This would amount to the so-called "conditional difference-in-difference" estimator.

In practice, the impact of the spillover effect on R&D investment may only materialize after some time of interacting with the university. Thus it would be desirable to consider not only two periods but allow for at least one further year of industry-science interaction before an evaluation is conducted.

In this example, I only refer to the R&D investment of the firm as variable of interest. However, evaluations could be extended to output measures such as patenting or sales with market novelties to investigate the nature of R&D conducted in firms collaborating with universities as response to preferential tax treatment. In similar spirit as the study of Belderbos et al. (2004b), one may hypothesize that university collaboration may lead to a change in the type of R&D conducted by the firm. R&D may become more basic or "radical" which may be reflected in more cutting-edge innovations that the firm introduces.

An alternative approach for estimating counterfactual situations in the context of innovation policy has recently been introduced by Takalo et al. (2009). They build a structural model that allows estimating R&D outcome under different policy regimes. In their paper they compare R&D in Finland under the current system of R&D grants with the hypothetical situation where the budget spent on R&D grants would distributed via R&D tax credits. In principle, this model could also be applied to the special case of extra incentives for industry-science collaborations within R&D tax credit schemes, but it is much more demanding in terms of data requirements and efforts in terms of empirical implementation.

Discussion

This paper discussed some economic aspects of the current policy practice of granting extra tax incentives to firms that engage in industry-science collaborations within R&D tax credit schemes of some EU member states.

As outlined, theories of industrial organization suggest that R&D collaborations may lead to higher R&D because firms can internalize potential external effects of R&D, that is, free-riding of other firms due to knowledge spillovers. Furthermore, it has been described that collaborations with universities or other public research institutions may lead to higher R&D than collaborations with horizontally related firms as the former do not exert a negative externality on profitability since universities are not involved in any market rivalry with the firm.

In addition to the potential knowledge spillover effect, business R&D may be influenced by subsidies. Granting extra R&D tax credits for industry-science collaboration is currently practiced in several EU member states. Thus, firms may benefit in two ways from the collaboration with science. First, they may benefit from knowledge spillovers and second, the extra tax incentives lower the price of R&D conducted in the firm.

As an outline for potential evaluations of these policies in European member states, I suggest an econometric analysis (difference-in-difference estimation) that allows estimating "treatment effects" of such policies. As an example, it is proposed to investigate the level of R&D investment in recipient firms, or more specifically, how R&D investment changes as a response to such policy. This is an especially interesting case, as the policy comprises two "treatment components". First, the extra tax incentive exerts a pure "monetary" benefit on the firm, as R&D becomes relatively cheaper when compared to other factor inputs. Second, the policy may induce firms to engage more in industry-science collaborations. If so, there may be a separate "spillover" effect that results in increased R&D investments at the firm level, in addition to the monetary effect of the subsidy.

However, industry-science collaborations may not be unambiguously welfare-enhancing. If it is believed that the primary task of university research is basic science and that results of basic science lead to higher welfare in the long run, one may ask whether basic research suffers from industry-science collaboration to some extent. Increased commercialization of university research may distract researchers from their basic research tasks. This assumption is not implausible as a firm typically seeks specific solutions for technological problems emerging in its business. Thus, engaging in industry-science collaborations may force university researchers to shift their attention to more applied research questions that possibly have to be addressed within tight deadlines. Basic research output might suffer under these circumstances. Czarnitzki et al. (2009) analyze this question using individual data of German professors. They correlate their publication counts and quality with patenting activity where patents are differentiated into purely academic patents and corporate patents. The latter are patents where the university researcher appears as the inventor and a firm as the patent applicant. This can be interpreted as an indicator for an engagement in industry-science collaboration. Regression analysis shows that such collaboration harms the publication output of the scientist with respect to both quantity and quality whereas commercialization activity measured as academic patenting does not. Lower (quality) publication output may be an indication of the opportunity cost of science-to-industry technology-transfer policies, especially if additional R&D tax incentives for industry-science collaborations are financed by reductions in basic public university budgets. The potential benefits to business R&D should therefore be carefully assessed against potentially negative effects occurring in knowledge output of public science.

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Annex 3

Financing constraints for industrial innovation: What do we know?

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Introduction

Innovations typically result from investment in research and development (R&D). From that perspective, R&D activities of firms can be seen as private investments in the creation of knowledge. This basic fact makes investment in R&D projects different from other types of investment.

R&D activities and resulting innovation constitute an important driver of economic competitiveness and hence sustainable economic growth. As has been illustrated by numerous studies, the impact of R&D on productivity at the firm level stems from the implementation of newly generated knowledge and technological discoveries into new products, improvement of existing products and production processes or cost reductions of producing existing products or services (see e.g. Stiglitz 1969, Griliches 1980, Schankerman 1981, Griliches and Mairesse 1984, 1990, and Hall and Mairesse 1995). Consequently, R&D has been recognized as important input factor to industrial production. Potential under-investment may have detrimental effects on competitiveness, on the creation of jobs and on long-run economic performance.

Underinvestment may occur for two main reasons that reduce incentives for private investments in industrial innovation. First, private returns to investment in R&D, that is returns to the company or organization undertaking the investment, are lower than social returns due to knowledge spillovers. Second, capital market imperfections, in particular information asymmetries between the parties involved, may lead to financing constraints for such investment reducing private returns even more. Hence - from a welfare perspective - too little R&D may be realized in (competitive) markets due to positive externalities and information asymmetries in lending and investing relationships. Both types of market failures are usually regarded as justification for government intervention that aims at promoting R&D investment.

The following sections provide a brief overview of the most important insights from economic literature on private investment in innovation and how it may be constrained by market failure.

Knowledge spillovers and incentives for investment in innovation

Generally, firms invest in order to realize returns from the investment. In the case of investments in the creation of knowledge the investment may not only provide benefits for the investing firms, but also for third-parties that are able to absorb (parts of) the knowledge that is being created. In a seminal paper, Griliches (1979) outlines the main sources of potential externalities generated by R&D activities in the form of knowledge spillovers. Knowledge spillovers arise because of the imperfect appropriability of the knowledge imbedded in innovations. In particular, (basic) research projects create knowledge that becomes, at least in part, available to third parties who do not compensate the firm which is conducting and financing these activities.

Thus, firms cannot appropriate the full benefits from its R&D while it has to bear the entire costs (Nelson 1959, Arrow 1962, Usher 1964). Incentives for investing in R&D may therefore be reduced and the extent to which private investment in R&D occurs is lower than socially desirable. The existence of a gap between private and social returns to R&D has been studied empirically using a range of approaches and measuring methodologies (see Hall 1996, 2002, and Hall and Lerner 2010 for comprehensive surveys of the literature). Knowledge spillovers arise via different routes and can occur voluntarily or involuntarily, e.g. via foreign direct investments, suppliers, customers, and worker mobility (see Cincera and Van Pottelsberghe de la Potterie 2001).

The magnitude of spillovers may vary across industries and by type of R&D activity. For example, there may naturally be more spillovers in knowledge-intensive industries (see e.g. Saxenien 1990, Acs et al. 1994, Feldman 1994, and Henderson et al. 1998).

Spillovers can occur within and across industries. Jaffe (1986) analyzes inter-industry and intra-industry spillovers finding that the latter are stronger. Also a recent paper by Belderbos et al. (2008) explicitly models intra-industry spillovers while previous literature mainly considered inter-industry spillovers. Spence (1984) started the theoretical spillover discussion showing that, on the one hand, R&D intensity decreases in the absence of perfect appropriability of knowledge, but that on the other hand innovation output increases through spillovers.

Cohen and Levinthal (1989, 1990) contribute to the spillover debate pointing out the importance of absorptive capacity for identification, assimilation and exploiting knowledge from the environment. The work by Cohen and Levinthal stimulated a debate on the necessary factors of absorptive capacity. Levin and Reiss (1988) show that R&D outcome increases with spillovers provided firms have complementary knowledge. A major part of the literature has focused on the internalization of knowledge and technology spillovers (Katz 1986, D'Aspremont and Jacquemin 1988, Kamien et al. 1992, see De Bondt 1997 for a survey). One of the key results from this literature is that private incentives to conduct R&D are reduced (as there is an incentive to free-ride) when R&D by one firm spills over to other firms. Thus, firms try to maximize incoming spillovers and to minimize outgoing spillovers (Cassiman and Veugelers 2002). One strand of the empirical literature focuses on the question how to measure spillovers and its impact on innovative performance (e.g. Audretsch and Feldman 1996, Lichtenberg and Van Pottelsberghe 1996).

Regarding the type of R&D, Griliches (1986) points out that (basic) research is a main driver for productivity at the firm level. He shows that expenditures for basic research significantly contribute to productivity growth of U.S. manufacturing firms in the 1970s (also Mansfield 1980). He finds in his cross-sectional analysis that firms that invest a larger fraction of their total R&D on basic research are more productive, hence stressing the importance of this component.[57] However, as noted most prominently by Arrow (1962) and Usher (1964) knowledge spillovers may be particularly relevant for the 'R' component of R&D. Thus, (basic) research, which is used as an informational input into subsequent inventive activities, is especially relevant for competitors and other agents that are able to absorb knowledge spillovers. This may reduce incentives to invest in long term research projects and may bring overall industrial research in the economy way below optimal levels.

The awareness of the lack of appropriability of returns on investments in knowledge has triggered the establishment of institutional and legal frameworks aimed to protect intellectual property and hence, make appropriability of returns more feasible. However, the fact that neither patents nor secrecy perfectly guarantee the full returns from an innovation suggests an innovation policy that focuses on supporting especially those firms that are expected to create largest spillovers to the economy. Additionally, policies promoting actions that allow internalizing spillovers, such as research joint ventures or other types of collaboration, may help to increase incentives for private R&D.

Yet, even if full appropriability of returns could be achieved, a second source of potential underinvestment, that is, access to financing for such investment, remains important.

Financing constraints for innovation

Like any investment, investments in innovation projects require financial resources. Innovation projects usually involve research and development (R&D) activities. R&D, however, is characterized by high, and usually firm specific investment costs on the one hand, and low collateral value, on the other hand. That is, establishing an R&D program involves significant sunk costs that are an expense and - unlike capital investment - cannot be capitalized in the balance sheet. Information asymmetries between investors and managers additionally create uncertainty that affects financing conditions. In principle, there are two sources for financing innovation projects. External sources such as bank loans or other debt contracts on the one hand,

[57] Recently, this finding has been complemented by Czarnitzki et al. (2009) who show that research expenditures exhibit a significant premium over development expenditures with regard to patent productivity in a panel of Belgian firms.

and internal sources, that is retained profits or (new) equity. Firms deciding about their optimal levels of investments will do so while choosing their capital structure in such a way as to minimize the long run cost of capital.

Only in a neo-classical world with frictionless markets would the source of financing not matter. The well-known theorem of Modigliani and Miller (1958) showing that investments decisions can be indifferent to capital structure holds for firms in markets where there are no taxes, no bankruptcy costs and no asymmetric information.

Since the work of Arrow (1962) and Nelson (1959) numerous articles have elaborated on concepts illustrating why the source of financing does matter and in particular matters for investments in the creation of knowledge. These considerations boil down to the recognition that, if capital markets are imperfect and information asymmetries influence lending and investment decisions, the cost of different kinds of capital may vary by type of investment (Meyer and Kuh 1957, Leland and Pyle 1977, Myers and Majluf 1984).

Thus investment in innovation compared to other types of investments is characterized by a high degree of asymmetric information between the parties involved. Complexity and specificity of innovation projects make it difficult for outsiders to judge their potential value. Moreover, firms may be reluctant to reveal details of the projects to potential investors for competition reasons (Stiglitz and Weiss 1981, Greenwald et al. 1984, Bhattacharya and Ritter 1983, Anton and Yao 2002). Lenders or investors may demand a 'premium' on their required rate of return in the sense of Akerlof (1970). If no pursuant rate of return can be appropriated, investors may ration their investment or even refrain from investing at all (Stiglitz 1985). For example Hall (1992), Himmelberg and Petersen (1994) and Czarnitzki and Hottenrott (2009a) show that internal sources of funds are indeed more important for R&D than for ordinary investment.

In addition to moral hazard problems between the management of the firm and outsiders, such as investors or lenders, information asymmetries between management and owners may impact investment in innovation projects and, hence financing conditions (Jensen and Meckling 1976, Grossman and Hart 1982, Czarnitzki and Kraft 2004).

Besides information asymmetries, the intangibility of the asset that is being created by the investment may make raising funds externally more costly for innovation than for other types of investments. A large fraction of innovation investments, particularly R&D, is sunk and cannot be redeployed (Alderson and Betker 1996). Debt-holders such as banks prefer physical and re-deployable assets as security for their loans, since those can be liquidated in case the project fails or in the event of bankruptcy. Moreover, serving debt requires a stable cash flow which makes financing of innovation projects by external sources more difficult, since most of these projects do not immediately lead to success. In addition, serving debt reduces cash flow for future investments (Hall 1990, Hall 2002).

There is a whole branch of theoretical and empirical literature illustrating that firms indeed first and foremost use internal funds to finance innovation projects (as compared to debt) indicating a gap in the cost of capital (Leland and Pyle 1977, Bhattacharya and Ritter 1983, Hall 1990, Hall

1992, Himmelberg and Peterson 1994, Bougheas et al. 2003, Czarnitzki and Hottenrott 2009a, b). Consequently, the extent to which financial constraints are binding depends on the firms' ability to raise external or internal funds under the conditions of imperfect capital markets.

Empirical evidence

Measuring financial constraints, and identifying firms that are affected, represents a challenge in empirical research. Since the seminal work of Fazzari et al. (1988) econometric studies have tried to detect financial constraints by analyzing investments' sensitivities to changes in available financial resources. This methodology has subsequently been applied to investments in R&D as such activities constitute an important share of total innovation investments. The conjecture for investment in R&D was derived accordingly: the more sensitive firms' R&D investment to cash flow the more binding are financial constraints. Excess sensitivities were regarded as indirectly reflecting firms' lack of access to the credit market.

As an alternative to this indirect approach, recent studies investigate firms' access to external funds more directly through the analysis of standardized credit ratings (Czarnitzki 2006, Czarnitzki and Hottenrott 2009a,b) or credit requests (Piga and Atzeni 2007). The main concern using credit requests, however, relates to a selectivity problem as the most constrained firms which do not expect to get external funding might not even ask for it. Moreover, the increased availability of comprehensive, internationally harmonized survey data on innovation activities at the firm level has enabled researchers to adopt more direct approaches towards the identification of potentially financially constrained firms (Canepa and Stoneman 2002, Savignac 2008, Tiwari et al. 2007). These studies generally define firms as constrained if the firms indicated in a survey that its innovation projects were hampered by the lack of finance. One problem that these studies face is the potential endogeneity of the survey indicator. Firms may be more likely to indicate "some" lack of finance, the more innovation projects they conduct and thus R&D they invest. The challenge is to find a valid instrumental variable which is not influenced by the R&D investment decision of the company, but does influence the survey variable "lack of finance".

As mentioned above, the theoretical literature stresses the role of asymmetric information, moral hazard in borrower-lender relationships, intra-firm organizational structures and other institutional factors that may increase the risk of firms to face financing constraints. Hence, empirical studies - primarily on manufacturing industries - focused on testing hypotheses derived from theoretical considerations. Existing research tackled the questions in multiple dimensions and from different perspectives.

Small and young firms

Himmelberg and Peterson (1994), Petersen and Rajan (1995), Berger and Udell (2002), Czarnitzki (2006), Ughetto (2008) and Czarnitzki and Hottenrott (2009a) among others analyze the role of firms' age or firms' size in terms of number of employees or assets. The studies by and large find evidence for the hypothesis that smaller firms are more likely to face financing constraints as they usually cannot provide as much overall collateral value compared to larger, more capital intensive firms. Moreover, younger firms may be restricted in their R&D investment due to additional factors that affect financing conditions. First, lower equity may increase interest rates required by potential lenders (Müller and Zimmermann 2009). Savignac (2008), for instance, corroborates that the probability of financing constraints decreases with firm size and depends on the firms' ex-ante financing structure.

Likewise, problems of asymmetric information may be less severe for older firms that have established a long and stable relationship with their bank. Young firms on the other hand have not yet built such a relationship (Petersen and Rajan 1995, Berger and Udell 2002). Moreover, established firms can innovate by building on their previous innovations, e.g. by product differentiation or improvement, while younger firms need to conduct more fundamental R&D which requires more resources and is much more uncertain. This may aggravate financing constraints since they cannot yet rely on internal funds resulting from cash inflow from former products either. Further, banks may be reluctant to finance innovation projects of young firms because of the 'initial-stage nature' of such projects and the overall higher default risk. This is also found using survey data (Canepa and Stoneman 2002, Savignac 2008, Schneider and Veugelers 2008).

However, small and young entrepreneurial firms contribute significantly to the introduction of major innovations not only in the US. Such firms tend to innovate more radically, create new technologies, products and markets and often lay ground for further innovations and spur innovation by other firms (Baumol, 2002). Financing constraints that hamper those firms' innovative efforts may thus be particularly harmful for the development of economic competitiveness and hence for sustainable economic growth.

Young innovative firms and innovation capacity

Recently, the firms' attributes that have been found to trigger financing constraints have been complemented with the firms' innovation profiles. First, the concept of New Technology Based Firms (NTBFs), generally defined as small and medium sized firms in high-tech sectors, has been introduced (Storey and Thether, 1998). Compared to growth rates of start-ups in general, NTBFs were found to grow faster in terms of employment indicating the potential for job-creation embedded in these firms. The slightly different concept of Young Innovative Companies (YICs) takes into account that in addition to the disadvantages of being small and young, these firms exhibit a high R&D-intensity in the sense that funds needs for investment in R&D are large compared to the funds that the firms generate from their business activities.

Moreover, may such firms find it more difficult to appropriate the returns from their investments in innovations if they lack appropriation strategies (Cassiman and Veugelers 2002) and/or complementary assets (Teece 1986, Gans and Stern 2003).

Additionally, it may be other firms that benefit most from the surplus created by the initial innovation by the YIC through subsequent innovations that build on the knowledge created by the YIC. Hence YICs may bear a high share of the risk of subsequent innovators.

Schneider and Veugelers (2008) find evidence for financing constraints for YICs in Germany using survey data. They find that YICs achieve significantly higher innovative sales than other innovation-active firms, but that access to finance is the most important factor that hampers YICs' innovation activities. Moreover, it does so significantly more than for other innovating firms. The authors also show that existing R&D subsidy schemes are in general effective, but not for YICs.

Also recently, Hottenrott and Peters (2009) introduce the concept of innovation capacity. This concept is based on the skill structure of firms' employees, innovation experience and firms' efforts to train their employees and can be applied to broader range of firms than the YICs-concept as it does not exclude firms that are not yet active in R&D and innovation. Using this more general concept on German manufacturing firms, the authors illustrate financial constraints do not depend on the availability of internal funds, size or age per se, but are driven by innovation capacity that determines resource requirements. That is, firms with higher innovation capacity are more likely to have unexploited innovation projects, independent of their financial background. Firms with high innovation capacity but low financial resources turn out to be most likely constrained. Yet, they also observe constraints for financially sound firms.

These empirical findings results suggest that if innovation capacity is the driving force behind financing constraints governmental action towards innovation policy that aims at supporting private investment in innovation activities should focus on the factors that form the innovation capacity of firms such as the accumulation of human capital.

Such policies may be able to account for the distinctive characteristics of YICs, but would address also firms that are not yet at a stage in which very high R&D-intensities can be observed. Hence the innovation capacity concept covers also those firms that are not yet very innovative probably due to financing constraints.

Type of R&D

Until recently, empirical, as well as theoretical, literature has paid little attention to the fact that R&D projects can differ substantially in terms of uncertainty of returns, resource requirements, risk of failure, involvement of basic research, the importance of secrecy and that these properties may affect financing conditions. Additionally, most articles, surveys, evaluations and reports concerning allocation of resources to R&D do not explicitly distinguish between the different components of R&D, namely research and development oriented projects. However, characteristics usually attributed to R&D activities in general, such as intangibility and outcome uncertainty are very likely to be more applicable for 'R' compared to 'D'. Research projects are also usually characterized by being "far from the market" and may induce higher externalities decreasing the likelihood of profitability. Moreover, development takes place at a much later stage of the R&D process building on previously generated knowledge.

An exception on the first issue is Kamien and Schwartz (1978) who, in a theoretical model, distinguish firms that are doing routine R&D to strengthen their established product lines and firms investing in more fundamental R&D projects aiming at more radical market innovations. According to this distinction, the former firms are less likely to face financial constraints on their activities than the latter firms. Since fundamental innovations usually involve basic research, require significantly more resources, are much riskier in terms of default and expected returns, and are more prone to secrecy issues, the acquisition of external capital may be curtailed.

Czarnitzki and Hottenrott (2009b) test this empirically by investigating R&D investments of product innovators where the type of R&D, with respect to the degree of innovativeness, is considered as being decisive for financial constraints. They show that firms pursuing cutting-edge R&D strategies are indeed subject to financial constraints in the credit market. R&D spending turns out to be curtailed for cutting-edge R&D while it is not for routine R&D investment.

A further study by Czarnitzki et al. (2009) explicitly takes into account the heterogeneity of the two components of R&D. By compartmentalizing industrial R&D activity into its components, they argue that financing development 'D' externally should be less critical than it is for industrial research 'R'. The empirical study, indeed, reveals that 'R' investment is more sensitive to the firms' operating liquidity than 'D' indicating that firms have to rely even more on internal funds for financing their research compared to development activities. Looking at aggregated R&D expenditures of the firm would not have revealed this effect. Moreover, they find that (basic) research subsidy recipients invest more into 'R' than other firms, and that their investment is also less sensitive to internal liquidity.

These findings have interesting consequences for policy. As cutting-edge innovations are generally regarded as the driving forces of technological progress and also yield higher social returns than routine R&D projects in the long run, this may call for policy measures towards cutting-edge R&D projects. Second, research-oriented projects may require distinct attention implying that a uniform R&D policy may not be able to alleviate constraints to a sufficient extent. Hence, calling for different policy support schemes for 'R' and 'D'.

Financial Market Regimes

Hall (1992), Himmelberg and Peterson (1994), Bhagat and Welch (1995), Hall et al. (1999), Mulkay et al 2001, Bond et al. (2006) study the role of financial market regimes. Hall (1992) and Himmelberg and Peterson (1994) find a positive relationship between R&D activity and cash-flow for US firms. Mulkay et al. (2001) show that cash flow seems to be more important for any type of investment in the US than in France. Bond et al. (2006) find that cash flow determines whether UK firms do R&D, but not how much, while they do not find such a relationship for Germany. In contrast, Harhoff (1998) confirms a positive sensitivity to cash-flow for German manufacturing firms. In a similar vein, a negative association between debt and R&D activity was reported for US but not for Japanese firms by Bhagat and Welch (1995). For US and UK firms they observe a positive correlation between stock return and R&D activity two years later. Bougheas et al. (2003) find similar results for Ireland. Canepa and Stoneman (2002) compare inter-country differences in Europe based on survey information and find a higher perceived importance of financing constraints on innovation for smaller firms in market-based systems.

Conclusion and final remarks

A number of conclusions can be drawn from this body of empirical literature. On the one hand, there is evidence that internal funds are a crucial source of financing for innovation. How much a firm has to rely exclusively on internal funds because credit is constrained depends on firm and project characteristics.

Moreover, macro factors such as the financial market system play a crucial role. Firms in so-called Anglo-Saxon ‘market-based’ economies with developed and liquid stock markets generally rely to a lesser extent on bank financing per-se compared to ‘banking-dominated’ financial systems that can for example be found in Europe. Such findings indicate that even in a globalized world financing constraints differ in their nature and consequently call for different solutions depending on the financial market environment faced by firms.

Not surprisingly private sector initiatives towards a solution for closing the funding gap for young firms and start-ups have been observed in Anglo-Saxon economies. Most prominently, the emergence and growth of the venture capital (VC) industry can be seen as an attempt to close the financing gap by reducing asymmetric information and moral hazard rather than simply subsidizing the investment (see for example Chan 1983, Lerner 1994a, b, 1995, 1998, Berglöf 1994, Hellmann 1998, Cornelli and Yosha 2003, Kaplan and Strömberg 2003 and Hall and Lerner 2010 for a recent survey). Gompers (1995), for example, shows that VC firms’ investment in early-stage companies and high-technology industries where informational asymmetries are significant is valuable.

Continental European economies have not witnessed a significant growth in the provision of VC. VC financing in most continental European countries is still rare and focused on a few (high-tech) industries, e.g. biotech. A recent study by Breuer et al. (2007) finds substantial differences between the German and the US VC markets. They suggest legal differences as well as cultural differences may cause the comparative underdevelopment of the German VC industry and the difference in the importance of debt financing (see also for example Mayer 1988, Bebenroth et al. 2009, and Deutsche Bundesbank 2000).

However, the VC solution to the problem of financing innovation is not only limited geographically, but also intrinsically. First, it focuses only on a few sectors at a time and often does not apply for small start-up investments. Second, for the VC solution to work VC firms must be given the opportunity to exit the investment at a certain point. This, however, requires well developed stock markets (see Bottazzi and Da Rin 2002 and Hall and Lerner 2010).

These limitations may also be the reason why public policy support programs for new and young firms have been established in the US as well as in other market-based economies.

The empirical evidence for incentive and financing problems for private sector investment in innovation projects has thus provided ground for governmental interventions to prevent welfare reducing underinvestment in innovation. Such policy actions include the protection of intellectual property, direct financial support of R&D and tax incentives for R&D as well as the encouragement of R&D collaboration and partnerships between firms and between science and industry. However, the results also show that designing efficient policy schemes is not straightforward as government funds are limited and support should hence be addressed to firms which are really constrained.

Given that independently of any financial crisis, economic theory and empirical evidence stresses the existence of financing constraints, the problem presumably will deteriorate as the current financial crisis will require banks to conduct an even more detailed risk assessment in the future. Ughetto (2007) addresses how systematic risk assessment techniques within the implementation of the New Basle Capital Accord affect financing of innovation, in particular the screening of innovative firms. As intangible investments like R&D are not reflected in the firms' balance sheets, financial statement-based estimations of firm value and creditworthiness (internal, but also external ratings) may penalize firms that invest in R&D at least in the short-run.[58]
Thus, both politics and industry fear the deterioration of firms' financing conditions for such activities as forward-looking innovation projects.

This calls for targeted policy support directed at the most constrained firms and those projects that are likely to face the largest gap between private and social returns. Several empirical studies have shown that for example public R&D subsidies may indeed work quite well as they do not crowd out private investment in R&D, but lead to additional investments and additional innovation outcome (e.g. David et al., 2000, Almus and Czarnitzki 2003, Aerts and Czarnitzki 2006, Czarnitzki and Hussinger 2004, Czarnitzki and Licht 2006, Czarnitzki et al. 2007, Hussinger 2008).

However, for any policy programs to be effective it appears to be crucial to not rely on a uniform R&D and innovation support policy, but to provide nuanced programs that address particular kinds of firms in particular ways. Based on the theoretical considerations and empirical evidence presented above, several target groups at the firm and project level can be identified. First, these groups turn out to be the ones most likely to be constrained. Second, the detrimental and welfare reducing effects of foregone investments by these firms is likely to be considerable. These groups do not exclude each other. Firms may fit into one or several categories.

- Small (and medium-sized) firms
- Young and start-up firms and firms with high innovation capacity
- Research projects or more fundamental R&D compared to development projects or routine R&D
- Firms in financial market regimes that may hamper a working VC market

[58] Ughetto (2007) finds that even if qualitative factors do as well affect the credit rating, these are usually not directly related to innovation. However, she also points out that some of the Italian banks in her sample have established loan schemes directed at 'technology-based activities' that apply special conditions in terms of interest and collateral requirements. However, the latter type of loans requires screening of external expert committees. It therefore remains to be evaluated how beneficial granting such loans is for these banks. See Czarnitzki and Kraft (2007) for potential consequences of the Basle II capital accord on financing investments, in general, and Czarnitzki and Kraft (2006) for short-run (negative) effects of R&D on firms' credit ratings.

How the financial crisis has impacted the financing conditions of innovation will provide a starting point for future research. In addition, the rigorous evaluation of existing policy schemes addressing financial constraints for the above mentioned groups of firms or type of investment appears to be a desirable task for (European) innovation policy.

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Annex 4: Summary of R&D tax incentives, 2008-2009

Country	Corporate income tax rate large/small firm	Rate on level	Rate on increment	Base for increment[1]	Expense base	Deducted from
		European Union and EEC Countries				
Austria	25%					
– special allowance		125%	(+)[2] 135%	3 yrs	Current expenses	income
– capital allowance		115%			Machinery, buildings	Income
– alternative refundable tax credit		8%			Current expenses	Tax
Belgium	33.99%/24.97%					
– investment deduction		13.5%			Machinery, buildings	Income
– withholding tax credit		75%			Research wages	Withholding tax
Czech Republic	21%	200%			Current expenses	Income
Denmark	25%					
– collaborative R&D with universities		150%			Current expenses	Income
France (refundable)	34.43%				Current expenses and depreciation	Income
– R&D 100 M euro		30%				
– over 100 M euro		5%				
Greece	25%		50%	2 yrs	Current expenses	Income
Hungary	16%					
– tax credit		10%			Research wages	Tax
– with/at universities		400%			Current expenses	Income
– other R&D		200%			Current expenses	Income
Ireland	12.5%					
– R&D expenditure			25%	2003 level	Current expenses and machinery	Tax
– R&D buildings		20%			Buildings	Tax
Italy	31.4%					
– tax credit		10%			Current expenses and machinery	Tax
– collaborative R&D		40%			Contracts	Tax
Malta	35%	150%			Current expenses	Income
Netherlands	25.5%/20%	14% large firm; 42 % small			Research wages	Income
Poland	19%					
– credit for technology purchases		30% large firm; 50% small			Machinery	Tax
Portugal	26.5%	20%	50%	2 yrs	Current expenses	Tax

Country	Corporate income tax rate large/small firm	Rate on level	Rate on increment	Base for increment[1]	Expense base	Deducted from
Spain	30%/25%					
– Tax credit		25%	(+) 42%	2 yrs	Current expenses	Tax
– Capital R&D		10%			Machinery	
United Kingdom	28%/21%					
– Small company (refundable)		175%			Current expenses	Income
– Large company		130%			Current expenses	Income

Other Countries

Country	Corporate income tax rate large/small firm	Rate on level	Rate on increment	Base for increment[1]	Expense base	Deducted from
Australia	30%					
- R&D allowance		125%	(+) 175%	3 yrs	Current expenses and machinery	Income
Brazil	34%					
- R&D allowance		160%			Current expenses	Income
Canada (federal)	19%/11%					
– Small company (refundable)		20%			Current expenses and machinery	Tax
– Large company		35%				
China	25%					
- R&D allowance		150%			Current expenses	Income
India	33.9%					
- R&D allowance		150%			Current expenses and machinery	Income
Japan	39.5% 29.3%					
– large (small) firm <10% research intensity		8% (12%)			Current expenses and machinery depreciation	Tax
– large (small) firm >10% research intensity		10% (12%)			Current expenses and machinery depreciation	Tax
– collaboration with universities and other R&D institutes		12% (15% small firms)			Current expenses and machinery depreciation	Tax
Norway (refundable)	28%	18%(20% small firms)			Current expenses	Tax
Turkey	20%					
- R&D allowance		200%			Current expenses	Income
United States (federal)	35%/15%		20%	Maximum 50% of current expenses	Current expenses	Tax

NOTES:
1. Average over specified number of years
2. (+) In conjunction with volume tax incentive

Sources: Compiled based on sources including Pro Inno Europe policy measures website http://194.78.229.57/index.cfm?fuseaction=page.display&topicID=262&parentID=52, *OECD Science and Technology Outlook 2008*, individual government publications and websites, R&D tax incentive alert websites and tax consultants.

Annex 5: Summary of R&D Tax Treatment of Collaboration and Location

Country or Region	Collaboration	Location	Comments
European Union and EEC Countries			
Belgium	Withholding tax credit: Since 2005, all companies collaborating with a European university or with Belgian research institutes are entitled to keep 75% of the withholding tax the researchers are supposed to pay		There are two conditions: (1) the researchers need to have more than a secondary school and (2) only the withholding taxes of researchers involved in the collaboration are eligible.
Denmark	Collaboration allowance: A 150 per cent allowance from taxable income is granted on company collaborative research at universities or public research institutions.		Companies that carry research in-house are allowed a 100% deduction of R&D expenses
Hungary	A 300% research and technology allowance from taxable income tax allowance: Incentive is offered in cases where company lab is located at university or public research institute		Regular 200% research and technology allowance is also available for subcontracted R&D activities if partner is public/non-profit research site
Ireland		Royalty income exemption: Irish tax residents may be *exempt* from tax on income from registered patents. The patents do not have to be registered in Ireland but substantially all of the work on the development and testing of the patented product or process must have been undertaken in Ireland.	
Italy	Since 2008 Italy offers a 40% tax credit if research contracts are assigned to universities and public research centres up to an overall		The incentive was introduced in 2007 at a rate of 15%, which carried a 5 percentage points bonus on the regular R&D tax credit

Country or Region	Collaboration	Location	Comments
	R&D expenditure cap of €50 million per year per company. That means if all R&D is performed in contract with a university or public research institute, the maximum tax credit earned is €20 million per year. (For comparison, the regular rate of the tax credit is 10 per cent and the maximum tax credit earned is €5 million per year.)		of 10% implemented in the same year. The current increase from 15% to 40% (amounting to a 30 percentage point bonus on the regular tax credit) has the objective to promote closer networking between the business and science communities and it is expected to have an important R&D intensity impact. A recent drawback for the tax credit is that the anti-crisis decree (Legislative decree 185/2008) has just introduced a reform that consists on the need to "book" the access to be able to apply the tax credit, which unfortunately cancels the automatism of the instrument. In the decree, the government has also introduced the following fixed budgetary ceilings: €375.2 million for the year 2008, €533.6 million for the year 2009 and another €65.4 million for the year 2011.

Country or Region	Collaboration	Location	Comments
Netherlands	R&D wages tax credit takes the form of a reduction of the tax and social insurance contributions by the business sector. It ranges from 14 % for large companies to 42% for small companies		Company does not need to spend on R&D in-house - as long as the R&D activities are performed on the basis of written *collaborative agreement* with other organizations which employ and pay wages to scientists and researchers, such as universities
Norway	In 2008, the cap regarding eligible costs in SkatteFUNN for R&D cooperation with research organizations was increased from NOK 8 million to NOK 11 million		
Spain	Collaboration tax credit: R&D expenditures on projects contracted with universities or other research organizations are given an extra tax credit of 10 per cent over the regular rate	Eligible R&D may be carried out abroad up to 25% of total project cost by a resident company	
United Kingdom		R&D expenditures of a domestic company incurred abroad are eligible for R&D tax allowance without specific limitations	
Other Countries			
Australia		Overseas R&D activities may be eligible for R&D tax concession if these activities cannot be carried out in Australia and if no more than 10 per cent of the total R&D expenditure relates to overseas R&D activities	

Country or Region	Collaboration	Location	Comments
Canada **- Ontario** **- Quebec**	Ontario Business-Research Institute Tax Credit (OBRI): of 20%, offered since 1997, refundable, capped at C$ 4 million , available to foreign subsidiaries Companies that enter into a research contract with an eligible university, public research centre or research consortium may claim a refundable tax credit of 35 per cent of qualified R&D expenditures. The tax credit is applicable to 80 per cent of contracted research and is refundable to all companies with Quebec tax losses.	Federal SR&ED tax credit: Up to 10 per cent of R&D wages and salaries of Canadian-resident employee is eligible if incurred abroad by a resident company, including a foreign subsidiary. The activities outside Canada must be directly undertaken by the company and must be done solely in support of R&D carried on by the company in Canada.	OBRI-eligible are: provincially-assisted universities, colleges of applied arts and technology, research hospitals and other prescribed non-profit research organizations Quebec collaboration tax credit covers all eligible R&D expenditures, whereas Regular R&D tax credit is based on wages
Chile	Collaboration tax credit: The taxpayer can reduce up to 46% of taxes paid for contracts that have been previously certified by The Chilean Economic Development Agency (CORFO). The R&D center must have sufficient means in Chile to perform activities in the country and must be previously be in CORFO's "Registered Centers List".		
Japan	Collaboration tax credit: companies that collaborate on R&D with universities and other not-for-profit research institutions are allowed a 12% tax credit	R&D expenditures of a domestic company incurred abroad are eligible for R&D tax allowance without specific limitations	In-house R&D is afforded an 8-10% tax credit depending on research intensity of the company
United States		R&D must be performed in the country to	

Country or Region	Collaboration	Location	Comments
		be eligible for research tax credit. Expenses incurred by national firms or foreign subsidiaries on R&D projects performed outside the country (*e.g.* salaries, travel costs of researchers) are not eligible.	

Source: Compiled from the OECD, national tax sources and Pro Inno Europe policy measures website
http://www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=262&parentID=52

Annex 6

Expert Group Seminar on Impacts of R&D Tax Incentives

Contributing to Europe's R&D Intensity and Innovation Capability

Agenda

Brussels, September 23, 2009

Location: CDMA Building (level -1)

Overview

The aim of the workshop is to allow the expert group to present its work and receive feedback.

There are three areas concerning tax incentives that are of special interest for this workshop: reviewing and improving the advice on the design and evaluation of R&D tax incentives; evidence on the impact of tax incentives on collaboration in research and innovation; and evidence concerning the impact of incentives on the location of R&D investments in Europe.

The current decade has witnessed a significant increase in the use of R&D tax incentives, spurred on by the need to stimulate private R&D investment, notably via the Barcelona target of achieving a 3 per cent R&D intensity ratio by 2010, of which 2% by the private sector. This raises the need to identify the impact of such practices and to analyse the design and evaluation of tax incentive schemes.

The seminar is intended for both R&D and innovation policy-makers and practitioners, including academic experts, who can contribute to and benefit from the presentations and discussion. Participants will be able to gain new insights and identify new issues and practices in determining the specific impacts of R&D tax incentives, as well as provide feedback to the Expert Group's work.

Agenda

9:30	**Registration**
10:00 – 11:00	**Opening Session** – *Introduction*: Tiit Jurimae/Richard Cawley and Jacek Warda – ***Keynote presentation***: Otto Toivanen, Director, Helsinki Center of Economic Research, *"R&D and Tax Incentives in an EU Context: A Critical Look"*
11:00 – 11:30	Coffee Break
11:30 - 12:30	***Session 1: : Location* –** Evidence on tax incentives and the location of R&D in Europe
	Presentation: Chiara Criscuolo, London School of Economics *Discussant*: Michele Cincera, JRC-IPTS/KFG-IRI
12:30 - 13:30	***Session 2: Collaboration* -** Evidence on the impact of tax incentives as an inducement to collaborate with universities, research institutions and among companies
	Presentation: Dirk Czarnitzki, Katholieke Universiteit Leuven *Discussant:* Otto Toivanen, Director, Helsinki Center of Economic Research
13:30 - 14:30	**Lunch Break** (within room location)
14:30 - 15:30	***Session 3: Design and evaluation guidelines – reviewing the experience***
	Presentation: Christian Hambro *Discussant*: Arie van der Zwan, Ministry of Economic Affairs, the Netherlands
15:30 - 16:00	Coffee Break
16:00 - 17:00	***Session 4: Roundtable on Tax Incentives as a Policy Tool for the EU***
	Panelists: Alessandra Colecchia, OECD, Rene Belderbos, University of Leuven, Ward Ziarko, Belgium Science Policy Office, Arie van der Zwan, Ministry of Economic Affairs, Netherlands, and Andrea Conte, DG EcFin, the European Commission
17:00 - 17:30	***Wrap up session: Where do we go from here?*** Jacek Warda (chair of expert group)