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Evaluation of SkatteFUNN

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Authors:	Andreas Benedictow, Emil Cappelen Bjøru, Fernanda Winger Eggen, Marthe Norberg-Schulz, Marina Rybalka og Rolf Røtnes

Samfunnsøkonomisk analyse AS

Borggata 2B

N-0650 Oslo

Org.nr.: 911 737 752

post@samfunnsokonomisk-analyse.no

Preface

SkatteFUNN was introduced in 2002 as a measure to increase research and development in the Norwegian private sector and has grown to become one of the most important policy instruments for this task. The scheme has previously been evaluated in 2008. The Ministry of Finance has commissioned Samfunnsøkonomisk analyse AS to conduct a new evaluation, presented in this report. The evaluation has been completed in accordance with the European Commission Staff Working Document, *Common methodology for State aid evaluations*.

As project manager, I would like to acknowledge the substantial input from Marina Rybalka, Fernanda Winger Eggen, Marthe Norberg-Schulz, Emil Cappelen Bjøru and Rolf Røtnes from Samfunnsøkonomisk analyse AS and Anders Håkansson and Tomas Åström from the subcontractor Technopolis Group. I would also like to acknowledge discussions with and comments from Christian Hambro, Karen Helene Ulltveit-Moe and Pierre Mohnen as our project advisors, Michael Spjelkavik Mark and Roger Bjørnstad as earlier project participators and the reference group members from The Ministry of Finance, The Ministry of Trade, Industry and Fisheries, The Ministry of Education and Research, The Research Council of Norway, The Norwegian Tax Administration, Innovation Norway and The confederation of Norwegian Enterprise (NHO). I especially want to thank Erik Fjærli from Statistics Norway and Ingvil Gaarder from the University of Chicago for helpful comments and suggestions as external referees on a previous draft. Samfunnsøkonomisk analyse AS is responsible for all the content of this report.

Oslo, 2 July 2018

Andreas Benedictow
Project manager
Samfunnsøkonomisk analyse AS

Summary

SkatteFUNN is a measure aiming at increasing R&D in the private sector. The Norwegian Ministry of Finance has commissioned Samfunnsøkonomisk analyse AS to conduct an evaluation of SkatteFUNN. We have evaluated whether SkatteFUNN 1) has a well-defined objective of common interest, 2) is designed to deliver the objective of common interest and 3) has a limited negative impact on competition and trade. The first two points address the impact on R&D investment, innovation and productivity and the potential for misuse. The third point refers to the effects on competition and trade and an assessment of the overall balance.

1) Does SkatteFUNN have a well-defined objective of common interest?

There is a general belief that investment in R&D is a key factor driving innovation and economic growth. The government can control public sector R&D investment but can also stimulate such investment in the private sector. Governments worldwide have therefore adopted various financial support instruments to promote R&D in the private sector. R&D tax incentives are among the most popular R&D policy tools.

NOU 2000: 7, which laid the foundation for SkatteFUNN, pointed out that to stimulate R&D in the private sector, it was necessary to supplement existing schemes with a broader scheme in order to embrace a wider range of R&D projects. At the time, firms conducting smaller R&D projects in particular made little use of established R&D funding schemes. The R&D tax incentive scheme SkatteFUNN was introduced in 2002 with the objective of enhancing innovation by increasing R&D investment in the private sector and particularly in SMEs.

The rationale is that firms will not invest the socially optimal amount in R&D, as positive external effects on other firms and society in general are not fully internalised by the individual firms. Such positive external effects include dissemination of knowledge, new products and production opportunities, which may increase productivity growth and total income in the overall economy.

Furthermore, the information possessed by the enterprise and the investor is typically highly asymmetric, implying higher investor risk. This adds to the difficulties of obtaining funding for R&D projects in the private market, especially for SMEs.

SkatteFUNN decreases firms' R&D investment costs through tax credit up to set caps. SMEs may receive a tax credit of up to 20 per cent of the eligible R&D costs for approved projects, whereas large firms may receive a tax credit of up to 18 per cent. If the tax credit for R&D expenses is greater than the amount for which a firm is liable in tax, the remainder is received through a tax settlement.

The scheme has a solid theoretic rationale, is widely utilised and has become the largest public support scheme for private R&D investment in Norway. We conclude that SkatteFUNN has a well-defined objective of common interest.

2) Is SkatteFUNN designed to deliver the objective of common interest?

The questions to answer here are a) does SkatteFUNN meet its operational target of higher R&D investment in the private sector and particularly in SMEs, b) does such investment fulfil the "real ambition" of

more innovation and higher productivity, c) is SkatteFUNN appropriate and well-proportioned to achieve these targets and d) what is the extent of misuse of the scheme?

a) SkatteFUNN significantly increases recipients' investment in R&D

Estimating additionality is crucial for evaluating whether public support contributes to increasing investment in R&D, such that aid is not merely redistribution from taxpayers to some firms. We applied two different approaches to estimate additional investment due to SkatteFUNN, i.e. *input additionality*.

The first approach finds that SkatteFUNN has a positive impact on R&D investment, but only for firms with R&D spending that is less than the cost cap.

The second approach studies how different changes in the scheme's cost caps have affected firms' R&D behaviour. This approach finds that overall, the input additionality of SkatteFUNN is high. For every NOK 1 of tax credit we estimate that R&D expenditures increase by more than NOK 2.

The effects vary considerably, depending on the type of change in the scheme and when the firms received SkatteFUNN for the first time (grouped into different generations of users). Overall, input additionality decreases over time. This is because new generations of SkatteFUNN users have lower additionality, while the earlier generations tend to maintain their higher additionality over time. Our interpretation is that the most competent firms were also the most efficient at signing up for SkatteFUNN. It follows that a large share of the initial pool of highly efficient firms signed up at the introduction of the scheme, and therefore accounts for an ever smaller proportion of subsequent generations.

The increased cost cap in 2009 does not seem to have had any additional effect, but this must be seen in the context of the financial crisis, when extra support was needed just to keep R&D investment going. The expansions in 2014 and 2015 are found to have had a positive additional effect, especially on the earliest generations of SkatteFUNN users. Our estimates of input additionality are consistent with the previous study of SkatteFUNN, i.e. that it is somewhat higher than is typically found by international studies of comparable schemes.

b) SkatteFUNN enhances innovation and productivity

We analyse the effects of R&D investment on several result indicators, including the effect of R&D investment on innovation and labour productivity. This is referred to as output additionality. Although there seems to be broad agreement that R&D tax incentives result in increased R&D investment, studies documenting the effectiveness of R&D tax incentives on innovation are rare.

We find that SkatteFUNN projects increase innovation in the form of new products, development of new processes and more patents. Moreover, our results show that SkatteFUNN projects have the same effect on labour productivity as privately financed R&D projects.

The external effects of R&D are difficult to measure quantitatively. We apply a "distance to R&D" approach to identify external effects, though the results of this econometric analysis are inconclusive. In our survey, however, SkatteFUNN users reported that projects have benefited the firms' customers in terms of better products or services. Moreover, most respondents answered that strengthened competitiveness and dissemination of competence through staff mobility and cooperation were results of the SkatteFUNN project(s).

c) Appropriateness and proportionality

Norway has several schemes supporting private sector R&D. SkatteFUNN is specially aimed at also including SMEs and small R&D projects. Our assessment is that SkatteFUNN is more suited to enhancing smaller R&D projects, than other R&D schemes, mainly due to the simple application procedures. SMEs have a relatively large share of small projects, and around half of the users are firms with less than 10 employees. This is a significantly larger share than in the other direct R&D support schemes, for example the Research Council of Norway's (RCN) User-driven Research-based Innovation programme (BIA).

A major advantage of SkatteFUNN, compared to many other national schemes, is its neutrality with respect to geographic location, industry, ownership and technology. As it is a rights-based, general scheme, decisions on R&D investment are left to the market. The fact that SkatteFUNN is available to all, without a time-consuming and costly application process (for the authorities as well as the firms), is also a major difference from other R&D-enhancing schemes, where firms need to apply for subsidies or participate in projects and networks. The application process for other R&D schemes is often a barrier to SMEs with small R&D projects and little or no experience with such processes. Other studies show that SkatteFUNN's input additionality is higher than that of other R&D support schemes.

As part of the evaluation, we have investigated how SkatteFUNN performs relative to other R&D schemes administered by Innovation Norway (IN) and RCN in terms of various indicators of the outcome of the R&D activity. We find that the most frequently reported outcome is the development of entirely new technical solutions, followed by testing and implementation of technical solutions new to the firm. This indicates that SkatteFUNN projects are first and foremost development projects aimed at improving a firms' products or services. We also find that SkatteFUNN projects have the same possibility of being new to the market as R&D projects supported by RCN in general, and a higher possibility than for projects supported by IN.

We conclude that overall SkatteFUNN is appropriate and well proportioned. However, we recommend some of the scheme and provide seven policy recommendations in chapter 10. The final section of this summary provides a brief overview of our recommendations.

d) Misuse of SkatteFUNN does occur, but several measures can be implemented to limit and prevent misuse

The extent of misuse of SkatteFUNN was analysed with the aid of selected empirical indicators and randomized inspections, in collaboration with the Norwegian Tax Administration. It is obviously challenging to measure misuse, as fraudsters make efforts to hide it. However, we have found clear indications that tax-

motivated misuse of the scheme does occur. From the characteristics of the audited Skattefunn recipients, we have estimated the upper bound for misuse in the form of reporting ordinary operating costs as R&D investment. After adjustment for misuse, SkatteFUNN's estimated impact is reduced. On average, however, even if we assume misuse is at the upper bound, one krone in forgone tax revenue still increases R&D investment by more than one krone.

To some extent, misuse must be accepted as one of the costs of a scheme intended to attract many firms. This is particularly so when, as in the case of SkatteFUNN, control routines and administrative expenditures are kept at a low level. However, we would argue that it is of great importance to keep a stricter eye on misuse in the future, and we recommend several measures to prevent and reduce misuse. In this report, we present a list of suggestions aimed at preventing and reducing misuse of the scheme.

SkatteFUNN is designed to deliver the objective of common interest

On balance, a) SkatteFUNN satisfies the operational target of higher R&D investment in the private sector and in smaller projects in particular, b) such investment fulfils the "real ambition" of more innovation and higher productivity, c) SkatteFUNN seems appropriate and well-proportioned to achieve the targets and d) misuse of the scheme occurs but may be reduced by relatively simple means. Thus, our evaluation leads us to conclude that SkatteFUNN is designed to deliver the objective of common interest, although we have suggestions for improving appropriateness and proportionality and to reduce misuse of the scheme.

3) Does SkatteFUNN have a limited negative impact on competition and trade?

We have assessed SkatteFUNN's impact on competition and trade, which has both positive and negative elements. Firstly, SkatteFUNN is neutral by design. As it is a general scheme, there is no selection bias related to receiving SkatteFUNN. There is a slight favouring of SMEs, which arguably has a positive impact on competition as it reduces the entry barriers and counteracts the bias towards large firms by other available R&D schemes. We do not find any evidence that firms receiving SkatteFUNN have any negative impact on non-beneficiaries.

Internationally, we find that a relatively small share of exporting beneficiaries receives more than the limit of de minimis aid. It is important to note that even if support exceeds this limit, this is not sufficient reason for concluding that there is an impact on competition and trade. Furthermore, recipients of SkatteFUNN are found to import more from foreign firms, which has a positive effect on Norway's trading partners.

To the extent that SkatteFUNN impacts competition and trade, this is probably also true of most of the other member states with similar arrangements, levelling out the distortions. Overall, we argue that the positive impact on competition and trade more than outweigh the negative.

Concluding remarks and central policy implications

We conclude that the benefits of SkatteFUNN, including increased R&D investment, innovation and productivity and beneficial effects on competition and trade, very likely exceed the costs of negative distortive effects and misuse. This leads us to a clear recommendation that SkatteFUNN be continued.

However, based on our analyses and empirical results we also propose several improvements for the scheme, including simplifications and further stimulation of more R&D and collaboration. The total cost and the original intention that SkatteFUNN should be a broad scheme stimulating R&D in many firms are considered. We are also suggesting several measures for addressing misuse of the scheme, to improve the efficiency and legitimacy of the scheme.

In brief, our recommendations for improving the incentives for R&D investment are to:

1) reduce the cost cap
2) increase the tax credit rate for intensive collaboration
3) increase the tax credit rate for firms new to SkatteFUNN
4) abolish the general differentiation of the tax credit rate between large firms and SMEs
5) increase the hourly cost cap for in-house R&D, followed by yearly adjustments
6) introduce the same cap on hourly costs for all R&D, not just in-house, and
7) improve control routines, conduct more frequent inspections and apply new sanctions.

We have also assessed the rationale of implementing a lower limit for project size in SkatteFUNN but concluded that we do not recommend this measure, see appendix D for a discussion. See Chapter 10 for a thorough discussion of the recommendations.

Contents

1 Introduction

SkatteFUNN is a research and development (R&D) tax incentive introduced in 2002. The scheme aims at stimulating R&D in firms and was initiated to enhance R&D in the private sector.

SkatteFUNN incentivise R&D investment in the private sector by decreasing the realised cost of R&D investment. Small and medium sized firms (SMEs) may receive a tax credit of up to 20 per cent of the eligible costs related to R&D for approved projects, whereas large firms may receive a tax credit of up to 18 per cent of eligible costs. The need to stimulate R&D in SMEs, to increase R&D in the private sector, was pointed out in NOU 2000: 7.[1]

To qualify as R&D, an activity must meet the definitions set out by the Research Council of Norway (RCN). If the tax credit is greater than the amount that the firm is liable to pay in taxes, the difference is paid in cash to the firm. If the firm is not liable for tax, the entire allowance is paid in cash.

The Ministry of Finance has commissioned Samfunnsøkonomisk analyse AS to conduct an evaluation of SkatteFUNN in accordance with the European Commission's guidelines.[2] The most recently updated methodology for state aid evaluations is outlined in the Commission Staff Working Document, *Common methodology for State aid evaluations* (European Commission, 2014).[3] The plan for evaluating SkatteFUNN was approved by ESA, cf. ESA Decision 249/15 / COL of 24 June 2015.[4]

SkatteFUNN was evaluated by Statistics Norway in 2008. We will refer to this work were appropriate.

The assessment of a public scheme providing aid to the private sector is fundamentally about balancing the potential negative impact on competition and trade and misuse of the scheme, with the potential positive impact in terms of contributing to achievement of well-defined objectives of common interest.

For that purpose, the Commission has established a test which consists of the following questions:[5]

1. Is the aid measure aimed at a well-defined objective of common interest?
2. Is the aid well designed to deliver the objective of common interest?
3. Are the distortions of competition and effect on trade limited, so that the overall balance is positive?

The first two questions address the positive impact of the scheme. The third question refers to the potential negative impact on competition and trade and compares the positive and negative effects of the aid.

1.1 A well-defined objective of common interest

To contribute to a common objective, the scheme must address a market failure.

The underlying argument for SkatteFUNN is that the level of R&D investment would be below the socially optimal level in absence of the scheme.

Firstly, the level of R&D investment would be too low due to the existence of positive externalities of R&D investment that are not fully appreciated by the deciding agents.[6]

[1] The scheme was introduced as a follow-up of the Official Norwegian Report (green paper), NOU 2000: 7 "Ny giv for nyskapning".
[2] Information related to SkatteFUNN has been transmitted to the EFTA Surveillance Authority, (ESA) in accordance with the provisions of the EU regulation 651/2014, as a scheme exempted from the notification requirement in the EEA agreement art 62. The size of SkatteFUNN implies that the Norwegian authorities are obliged to conduct an impact evaluation in line with the European Commission Staff Working Document, *Common methodology for State aid evaluations*."
[3] This document outlines the necessity for following a comprehensive plan in an evaluation of a state aid scheme.
[4] Click here to read the approval.
[5] See Common principles for an economic assessment of the compatibility of State aid under Article 87.3.
[6] Externalities refers to situations when the effect of production or consumption of goods and services imposes costs or benefits on others which are not reflected in the prices charged for the goods and services being provided.

Secondly, there may be information asymmetries causing market failure in funding R&D investment. For instance, firms have better market knowledge and product understanding than banks and investors, causing credit or liquidity constraints. This is especially an issue for SMEs and start-ups.

In this evaluation we will assess whether SkatteFUNN has the intended effects, i.e. does it enhance R&D investment and innovation in the private sector. This assessment includes evaluation of both direct and indirect effects.

The direct effects relate to the intended impact on the course of action taken by the beneficiaries, the impact on additional R&D investment and whether private R&D investment match the forgone tax revenues.

The indirect effects are not directly targeted by the policy, but positive spillover effects caused by SkatteFUNN. Among these spillovers, the European Commission Staff Working Document, specify employment and productivity as result indicators. Increased collaboration between beneficiaries and approved research institutions could also be an indicator of spillover effects, as the information sharing most likely eventuate in a wider dispersal of the gains from R&D.

Productivity is an important indicator of an economy's competitiveness. Productivity growth enables a more efficient use of scarce resources and is a gain for the individual firms and for the whole economy.

1.2 Is SkatteFUNN well designed to deliver the objective of common interest?

In most countries, there is a variety of instruments in place to stimulate R&D. The government produces R&D on its own, through universities and publicly backed research institutions, and enforces intellectual property rights and the rule of law.

There is an international consensus that governments have a role in encouraging R&D investments in the private sector. Competition authorities ensure that market power is not concentrated in a way that reduce the incentive to invest in R&D. In general, governments are actively promoting well-functioning capital markets.

Furthermore, an increasing number of governments are offering support to increase spending on R&D in the private sector through direct and indirect measures. R&D tax incentives are, internationally, among the most popular innovation policy tools.

This evaluation assesses whether SkatteFUNN is an appropriate policy instrument to address the objective, including a comparison of SkatteFUNN's estimated impact and the cost of the scheme.

It is crucial to consider whether the same impact could have been achieved with lower costs or more effective measures (for example direct grants). Evaluating the impact of other R&D measures is not included in the mandate of this evaluation. However, by reviewing evaluations done by others we have assessed the impact of alternative instrument.

We will also debate whether the positive impact of SkatteFUNN can be hampered by misuse, and how compliance can be ensured.

1.3 Does SkatteFUNN distort competition and trade?

One negative impact of a public scheme, mentioned in the European Commission' Staff Working Document, is the potential negative impact on competition and trade.

To analyse the impact on competition and trade, we have identified when such effects may occur. This

is done by identifying whether SkatteFUNN has an impact on domestic competition, whether beneficiaries are active in export markets, and to what extent.

1.4 Outline

Chapter 2 discusses the common objective of the scheme and its historical background, in addition to descriptive statistics of the beneficiaries of SkatteFUNN.

Chapter 3 provides an overview of international R&D tax incentives, including a summary of international evaluations of such schemes.

In chapter 4, we present our estimated input additionality of SkatteFUNN. Input additionality is defined as the firms' R&D investment that can be attributed to SkatteFUNN relative to the size of the forgone tax revenue from financing the scheme.

The estimated output additionality is presented in chapter 5. Output additionality refers to SkatteFUNN's impact on innovation, production and profitability.

In chapter 6, we analyse the outcome of SkatteFUNN projects, including types of R&D and collaboration between firms and research institutions.

Chapter 7 compares SkatteFUNN to alternative R&D measures and presents firms' opinions of the administrative characteristics of SkatteFUNN, including their view on the application and reporting process.

In chapter 8, we discuss lack of compliance and the potential of misusing the scheme, including empirical indicators of misuse. We also put forward our recommendations for reducing the scope of misuse.

Chapter 9 contains a discussion of SkatteFUNN's potential impact on domestic and international competition and trade.

Finally, in chapter 10, we summarise our findings by assessing the balance of the benefit of SkatteFUNN, i.e. the value-added from increased R&D investment, and the social cost of the public contribution (cost of taxation), the net impact on competition and trade and misuse of the scheme. We also put forward our recommendations for enhancing the scheme's appropriateness and proportionality.

2 SkatteFUNN - The Norwegian R&D tax incentive

SkatteFUNN is a general R&D tax incentive implemented in 2002. The objective is to broadly stimulate R&D projects in the private sector, especially smaller projects. About half of the beneficiaries are firms with less than 10 employees and more than 80 per cent are firms with less than 50 employees. SkatteFUNN was proposed and implemented as a neutral scheme, giving firms with R&D projects the right to a tax deduction of up to 20 per cent of the eligible costs related to R&D investment.

Approximately 20 per cent of the beneficiaries of SkatteFUNN each year are new. Thus, the main share of firms receiving an R&D tax credit are "regulars" and firm age among the beneficiaries of the scheme has naturally increased over time. Slightly less than half of the SkatteFUNN beneficiaries have no prior R&D experience and more than 40 per cent of the firms receive public support only through SkatteFUNN.

Firms within three industries stand out as frequent beneficiaries of the scheme; advanced manufacturing, ICT and professional, scientific and technical activities. The two latter groups have increased their share of the total number of beneficiaries throughout the period.

In this chapter, we present the rationale for public funding of private R&D investment, the objective and history of SkatteFUNN and characteristics of beneficiaries.

2.1 Rationale for public funding of private R&D

R&D comprise creative and systematic work undertaken to increase the stock of knowledge. R&D leads to new ideas and translate into new and better products and improved productivity. Eventually R&D will increase general welfare in the economy.

Theory suggests that economic returns and growth are maximised when markets are free and well-functioning. In well-functioning markets, resources are allocated to where they create the most value (Smith, 1776). However, not all markets are well-functioning. Information asymmetries, externalities and public goods are examples of market imperfections. Without correction of market imperfections, an unregulated market will lead to inefficient use of resources (Strøm & Vislie, 2007).

Firms invest in R&D to increase profitability through technological development, improved processes and new knowledge. If a firm succeed in developing new ideas, and hence new or improved products, these can easily be copied and utilised by other firms.[7] One firm's R&D investment will thus gain other firms as well. However, the gains that accrue other firms are not considered in the inventing firm's assessment of how much it should invest. It is well-recognized in economic literature that investing in R&D has positive external effects, i.e. the broader economic effect of R&D investment exceeds the private economic effects (Arrow, 1962). Baumol (2002) argues that less than 20 per cent of the total economic gains from new technology and new products is accrued to those investing directly or indirectly in the innovation process.

Furthermore, it is often difficult for firms to obtain funding for innovation projects in the private market. The information possessed by the firm and the bank or investor is typically highly asymmetric, causing higher risk. Typically, external investors must put a lot of effort into understanding an R&D project's full

[7] Firms may patent their inventions to prevent others from exploiting them commercially. However, many innovations cannot be patented, or it is not expedient. Patent periods will also expire. Regardless of patenting, other firms than the inventor will be able make use of the new or improved product to improve their own production or working progress (e.g. make use of new software).

potential and risk. In general, there will be a tendency for investors to prioritise projects that are easier to understand than projects that require extensive inside knowledge from the firm (or researcher) who is doing the research. Thus, asymmetric information reinforces the tendency towards a socially sub-optimal level of R&D investment in the private sector.

Firms' underinvestment in R&D has given rise to publicly funded schemes of private R&D. The schemes aim at increasing investment from the profit maximising level of the individual firm to(wards) the socially optimal level. All OECD countries are currently spending significant amounts of public resources on schemes intended to stimulate private R&D investment. Internationally, R&D tax incentives, granting tax credits on eligible R&D expenditures, have become a major tool for promoting R&D (OECD, 2017).

By reducing costs, R&D tax incentives are expected to initiate R&D projects that otherwise would not have been initiated or increase investment in already initiated R&D projects.[8] It is worth mentioning that the relationship between firms' expected risk and subsequent cost of R&D, determines how many R&D projects will be carried out. The cost of an investment plays a significant role of perceived risk. The higher the cost, the greater the risk.

2.2 Implementation of SkatteFUNN

As part of the Norwegian parliament's review of the Revised National Budget for 2001, the government was asked by the parliamentary majority to put forward a proposal of a tax deduction for firm's R&D expenditures in line with the proposal in NOU 2000: 7 (Andersen, 2001).

NOU 2000: 7 originally proposed a scheme giving all firms 25 per cent funding of eligible R&D expenditures up to NOK 4 million per year (NOK 8 million per year for collaborative projects with universities, colleges and approved research institutes). With a higher tax-deductible amount for collaborative projects, the proposed scheme was specifically aimed at promoting collaboration (NOU 2000: 7, s. 215).

Furthermore, referring to studies and data showing that SMEs typically find investment in R&D too risky and resource intensive, the committee suggested that the proposed scheme should target small projects in particular.

The committee believed stability over time was important to maximize the scheme's impact (NOU 2000: 7). The majority of the committee voted to design the scheme as a deduction in tax payable. Furthermore, the committee underlined explicitly that the proposed scheme was not meant to replace direct funding from RCN's schemes, but rather complement existing schemes.

The Government (Stoltenberg I) first followed up the recommendations in NOU 2000: 7 by implementing the FUNN scheme in July 2001. FUNN was designed as a grant scheme aimed at collaborative projects between firms and universities, colleges and research institutions. Firms received a grant when purchasing services from these organisations. The scheme applied to all firms (including self-employed) but specifically aimed at reaching SMEs (Ot.prp. nr. 1 (2001-2002)).

It was the Government's view that a regulated grant scheme was more appropriate to accommodate the Parliament's intention to enhance R&D in the private sector. It was argued that a grant scheme would be administratively simpler and better attend

[8] We test whether this is the case for the Norwegian scheme (SkatteFUNN) in chapter 4.

firm's liquidity needs (Ot.prp. nr. 1 (2001-2002)). Nevertheless, based on the decision of the Parliament, the Government proposed to implement SkatteFUNN, a Norwegian R&D *tax incentive*, in the National Budget for 2002. This was adopted by the Parliament in December 2001 and the scheme was made applicable for the 2002 income year.

The Ministry of Finance proposed that SMEs should be allowed to deduct 20 per cent of their R&D expenditures, up to NOK 4 million per year and up to NOK 8 million when purchasing services from universities, colleges and research institutions. It was, and still is, a prerequisite for the deduction that the R&D project has been approved by RCN (Ot.prp. nr. 1 (2001-2002)). The scheme was expanded to apply to all firms in 2003.

2.2.1 Eligible beneficiaries and costs[9]

Firms applying for SkatteFUNN must have a permanent establishment in Norway and be liable to pay corporate tax to Norway.

SkatteFUNN is neutral along most dimensions. The scheme applies to all firm sizes, all industries and all types of firms, irrespective of geographic location. Firms decide themselves which projects to invest in and are eligible to apply for tax credits if they seek to develop a new or improved good, service or production process. The R&D projects promoted by SkatteFUNN can be within all disciplines but must generate new knowledge, skills or capabilities within the firm.

The required conditions to receive tax deduction for R&D expenses are described in § 16-40 of the Tax Act (of 26 March 1999). The scheme distinguishes between SMEs and large firms by differentiating the share of R&D expenditures they can receive in tax deductions; 20 per cent for SMEs and 18 per cent for large firms.[10]

Firms may submit multiple SkatteFUNN applications, but there is an upper limit on expenditures being eligible for tax deduction per firm per year, depending on whether it is intramural or purchased R&D from an approved research institution. Today these limits are NOK 25 and 50 million respectively, e.g. the maximum tax deduction for intramural R&D is NOK 5 million for SMEs and NOK 4.5 million for large firms. In addition, a maximum of 1,850 hours per employee per year is accepted when calculating the cost of intramural R&D. The hourly rate is set to 0.12 per cent of the employee's nominal annual salary but must not exceed NOK 600.[11] That is, for an employee with an annual salary of NOK 450,000, the firm can multiply NOK 540 (NOK 450,000 x 0.0012) by the number of hours the employee is working on the project when calculating the R&D costs. For an employee earning NOK 700,000 the firm must use the hourly wage rate of NOK 600 (NOK 700,000 x 0.0012 = NOK 840).

The cap of NOK 600 per hour limits the total intramural R&D firms can report per project. However, it is important to distinguish what the firms could have reported and how much of their actual costs the tax credit cover. For a full-time employee, a firm can claim a tax credit of maximum 20 per cent (if SME) of NOK 600 x 1,850 hours = NOK 1,110,000, i.e. NOK 222,000. If the firm has a 40 per cent overhead cost per employee, an employee with an annual salary of NOK 500,000[12] costs the firm NOK 700,000. Thus, the tax credit covers 32 per cent of the firm's costs. However, if the researcher has an annual salary of NOK 800,000, the firm's cost, with 40 per cent

[9] This section is mainly based on information on the scheme's webpage. Click here to see this page.
[10] To be eligible for the 20 per cent SMEs' tax credit rate the firm must have less than 250 employees and a maximum of € 50 million in operating income.
[11] See chapter 0 for changes in the different limits.
[12] The annual salary corresponding to exactly NOK 600 per hour whit a calculation rate of 0.12 per cent.

overhead, will amount to NOK 1,120,000. The tax credit is still no higher than NOK 222,000 and, in this case, amounts to 19,8 per cent of the labour cost. Hence, for employees with an annual salary above NOK 800,000 the tax credit will no longer cover 20 per cent of the actual project costs.

If the tax credit for the R&D expenditures exceeds the amount liable to pay in taxes, the remainder is paid out in cash to the firm. Firms that are not in a taxable position will receive the entire amount as cash grants. This feature is not present in many other, otherwise comparable, national schemes. However, it is arguable important as R&D intensive firms, in particular, typically spend their early years in a tax loss position.

2.2.2 Application and reporting process[13]

SkatteFUNN is jointly administered by RCN and the Norwegian Tax Administration. RCN is responsible for the approval of the R&D content of the project, whereas the Tax Administration assesses and grants the actual tax credit, i.e. deciding what the eligible costs are, which tax credit is appropriate (18 or 20 per cent) and any deduction due to other public support to ensure that limits for total state aid are respected.

RCN's task is to determine, ex-ante, whether the project can be considered R&D in terms of the law. The project shall be limited and aimed at acquiring new knowledge, skills and capabilities that are aimed at the development of new or improved products or methods of production. If RCN identify activities that are not considered R&D, such as marketing of a new product, the application will either be rejected, or the approval will exclude the marketing activities.

Firms are obliged to have separate project accounts that show how many hours each employee has worked on the project, which part of the project the employee worked on and their hourly cost. These accounts are to be kept on a continuous basis. Firms with approved projects must report back to RCN on an annual basis.

Claims for tax deductions are forwarded with the annual tax return, and costs incurred during the tax year can be included.[14] Auditors and the tax authorities must determine whether the costs stated by the firm are correct and sufficiently documented.

If the sum of the tax deduction and other grants to the project exceeds the limits of tax-deductible expenditures or the limits for State aid in EU regulation 651/2014, the tax authorities will reduce the tax credit accordingly.

2.2.3 Changes in the scheme

There have been several changes in SkatteFUNN since its implementation in 2002. At the time the scheme was implemented it only applied to SMEs and the R&D tax credit of 20 per cent was limited to investment up to NOK 4 million in intramural R&D or NOK 8 million in total R&D (i.e. including purchased R&D). In 2003 the scheme was extended to all firms, but with a lower tax credit for large firms (18 per cent).

Based on an evaluation of the scheme's financial management and administration, including the possibilities of misuse, a maximum hourly rate for personnel and indirect costs was introduced in 2007 (The Norwegian Government Agency for Financial Management, 2006). The maximum hourly rate was limited to NOK 500, in addition to a maximum number of hours per employee of 1,850.

[13] This section is mainly based on information on the scheme's webpage. Click here to see this page.

[14] Firms must submit an RF-1053 tax form approved by a state authorized auditor along with their income tax return.

In 2009 the threshold for R&D tax credit was increased to NOK 5.5 million in intramural R&D and NOK 11 million in total R&D.[15] The increase was one of the government's (Stoltenberg II) several tools to dampen the effect of the Global Financial Crisis (St.prp. nr. 37, (2008-2009)) and based on recommendations in Statistics Norway's evaluation of the scheme in 2008 (Cappelen, et al., 2008).

In 2011, the maximum wage rate was increased to NOK 530 and the calculation rate was reduced from 0.16 to 0.12 per cent of the employee's nominal annual salary. In addition, there was a change in the definition of SMEs and R&D in 2011, in direction of a more generous scheme (larger firms included as SMEs and a wider definition of R&D).

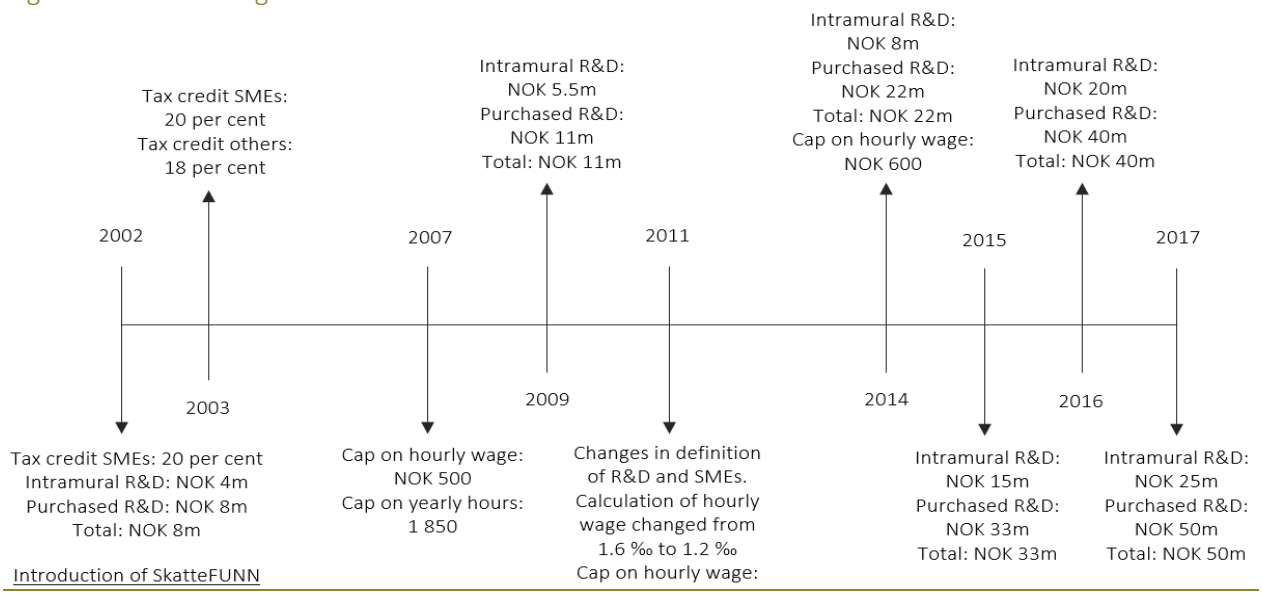
A further increase in the threshold for tax-deductible expenditures was made in 2014, as well as an increase in the maximum hourly wage rate. The thresholds were increased to NOK 8 million for intramural R&D and NOK 22 million in total R&D. Furthermore, the maximum hourly wage rate was increased to NOK 600.

Since 2014, there has been three consecutive increases in the limits for deductible expenditures, cf. figure 2.1. For 2017 and 2018, the threshold for intramural R&D is NOK 25 million and NOK 50 million for total R&D (intramural and purchased).

The latest increases in the thresholds are intended to stimulate increased R&D collaboration between firms and research institutions and contribute to implementation of more profitable R&D projects (Prop. 1 LS, (2013-2014)).

Ex-ante and ex-post assessments of adjustments in the scheme provide valuable information about its impact. The changes mentioned above are thus central in our evaluation (cf. chapter 4 and 5).

Figure 2.1 Main changes in SkatteFUNN



Source: The Ministry of Finance

[15] We exploit this change in our evaluation of the scheme's input additionality in chapter 4.

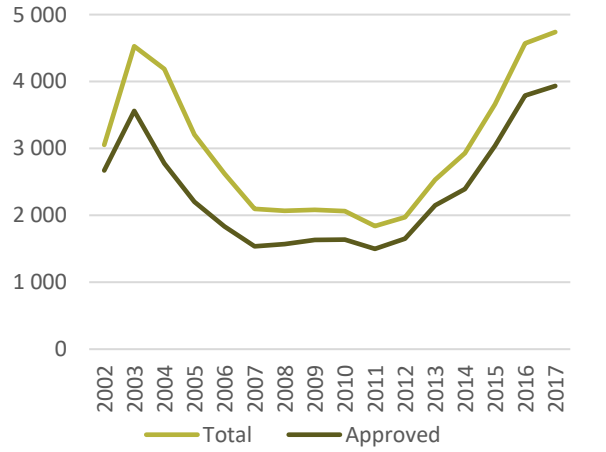
2.3 Use of SkatteFUNN

SkatteFUNN started with a relative high number of applicants and with the expansion of the scheme to all firms (not just SMEs) in 2003 the number of applications naturally increased significantly, cf. Figure 2.2.[16] However, the share of approved applications decreased.

The number of applications fell each year until 2008 and then stabilised in the aftermath of the global financial crisis. Just looking at the number of applications, the increase in the cap for tax-deductible expenditures in 2009 did not seem to have an immediate effect on the number of applications. However, apart from 2011, there have been an increase in the number of applications to SkatteFUNN, as well as a continuous increase in approved projects.

Compared with the decline in the number of applications between 2003 and 2008 (a reduction of 55 per cent), the fall in forgone tax revenues (total tax deductions) was relatively moderate, cf. Figure 2.3.

Figure 2.2 Total number of SkatteFUNN applications and approved applications[1]



Source: RCN

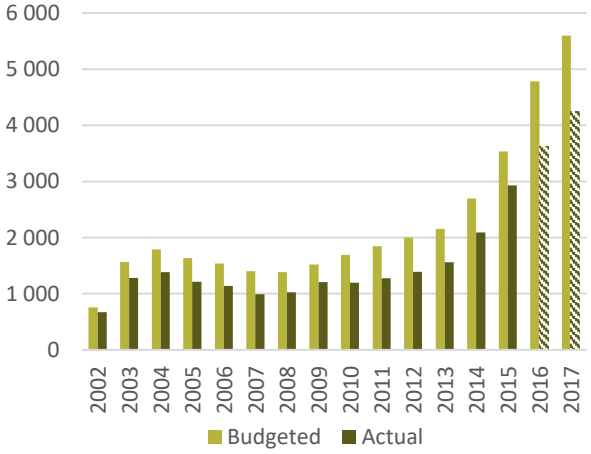
1) The total number of applications for 2017 are based on the status per 3 January 2018. Approved applications for 2017 are calculated based on the share of approved applications in 2016 (83 per cent).

With increases in the limits for tax-deductible R&D expenditures and the number of approved applications, the total amount of tax deductions has increased significantly since 2009. Total tax deductions are estimated to about NOK 4.2 billion in 2017.

However, most of the SkatteFUNN beneficiaries' projects are still small and received an annual tax credit equal to 0.72 million NOK or lower, cf. figure 2.4. Only 12 firms in 2014 and 2 in 2015 got a maximum possible amount of tax credit for both intramural and purchased R&D.[17]

We are aware that the increase in the total number of SkatteFUNN applications in the previous years is partly because RCN has taken it upon themselves to mobilise firms to apply for SkatteFUNN. Thus, the increase in number of applications is not necessarily an increase in firms' R&D activity but merely an increase in R&D active firms applying for an R&D tax credit.[18]

Figure 2.3 Budgeted and actual tax deductions. NOK million. Current prices[1]



Sources: RCN and the Norwegian Tax Administration

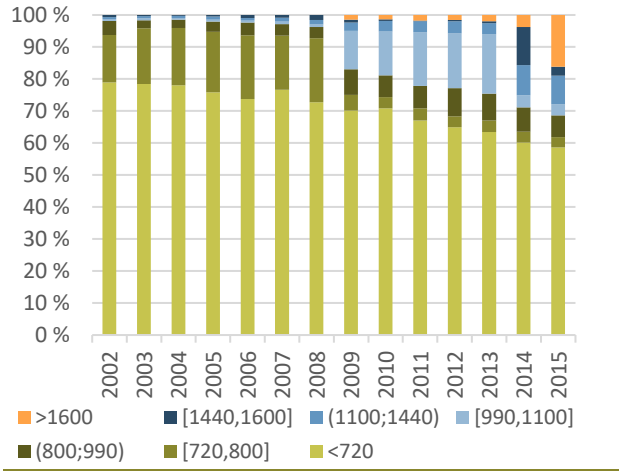
1) Actual tax deductions in 2016 and 2017 are calculated based on budgeted deductions and actual deductions average share of budgeted deductions for the period 2002-2015.

[16] The first couple of years the number of approved applications also exceeded the number of approved applications for other programs in RCN.

[17] We do not have the necessary data to divide firms by the size of their tax credits for 2016 and 2017.

[18] The previous evaluation (and our data) showed that there are several firms that do invest in R&D, but do not apply for SkatteFUNN. Thus, the increase in number of applicants does not necessary imply an increase in R&D activity.

Figure 2.4 Share of SkatteFUNN beneficiaries by tax credit size (in thousands of NOK)



Sources: RCN and the Norwegian Tax Administration

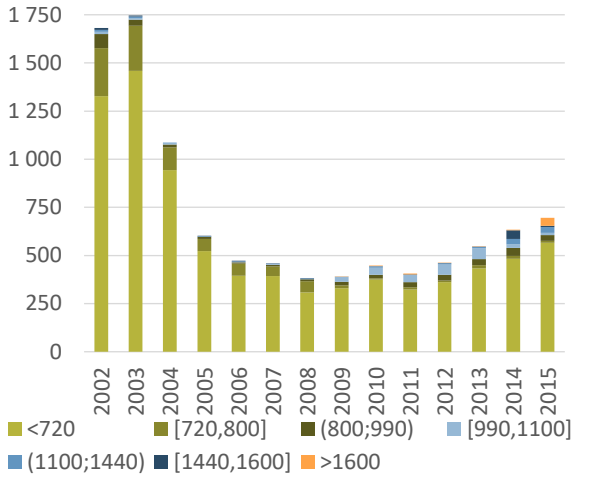
The number of new beneficiaries of SkatteFUNN has increased in the period after 2009, cf. figure 2.5. However, compared to the first three years after the introduction of the scheme, the annual number of new beneficiaries is relatively low.

Furthermore, most of the new SkatteFUNN beneficiaries start out with relatively small projects, with total costs below NOK 4 million (the initial limit for tax-deductible R&D expenditures), i.e. tax credit below NOK 720,000, cf. Figure 2.5. The share of firms with project costs below NOK 4 million varies from 76 to 87 per cent for all new beneficiaries of SkatteFUNN between 2002 and 2015.

In 2014 and 2015, we observe several R&D intensive firms with large projects (total costs of at least NOK 8 million) among the new beneficiaries of the scheme. Their share increased from under 0.5 per cent between 2002 and 2013, to over 7 per cent in 2014.

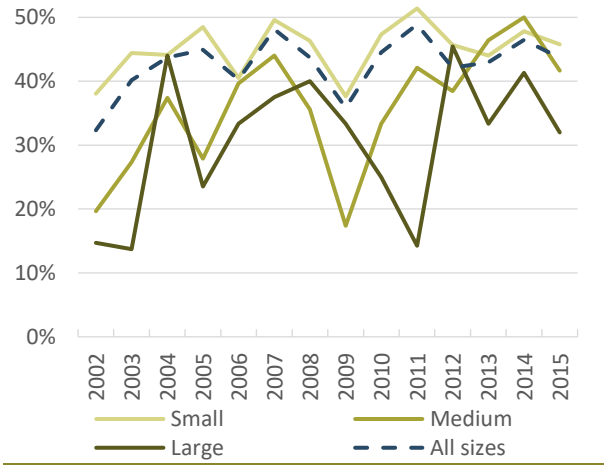
With some variation over time, a little under half of all new beneficiaries of SkatteFUNN have not been investing in R&D during the three-year period prior to their first application for SkatteFUNN, cf. Figure 2.6.[19] However, the share also varies a lot depending on the size of the firms' first SkatteFUNN project and is notably lower for firms with larger projects.[20]

Figure 2.5 Number of new SkatteFUNN beneficiaries, by tax credit size (in thousands of NOK)



Sources: RCN and the Norwegian Tax Administration

Figure 2.6 Share of new SkatteFUNN beneficiaries with no R&D activity in the three-year period prior to application, by project size



Notes: Small projects are projects with total R&D costs below NOK 4 mill, medium with total costs between NOK 4 and 5.5 mill and large with total costs above NOK 5.5 mill

[19] This share was highest in 2007 and 2011 (about 50 per cent), i.e. in the years when the cap for the hourly wage rate and the new definition for R&D were introduced. The share was lowest in 2002 and 2009 (32 and 36 per cent respectively), i.e. the year the scheme was implanted at the first post-crisis year. The latter possibly indicates that more R&D experienced firms applied for SkatteFUNN as an economic relief.

[20] The share is on average 45 per cent for new SkatteFUNN beneficiaries with small projects, 36 per cent for those with medium and 31 per cent for those with large projects.

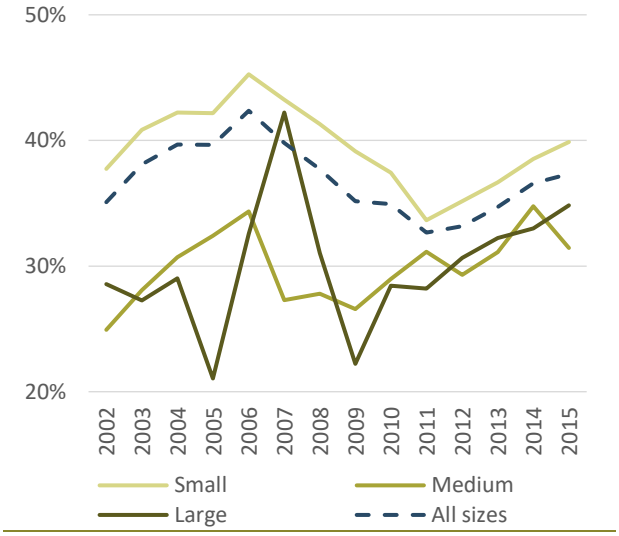
To receive SkatteFUNN it is a requirement that the firm is taxable in Norway. However, it is not a requirement that the firm is in a tax position, i.e. has tax liabilities.[21] Most SkatteFUNN beneficiaries are not tax liable, cf. Figure 2.7.

The share of SkatteFUNN beneficiaries that were tax liable was about 40 per cent up to 2008, before decreasing to 32 per cent in 2011. Since then, the share has increased but is still below 40 per cent. Due to the relatively low share of tax liable firms, most of the tax credits are paid out to the firms as grants, whose development is roughly the inverse of the development in the share of tax liable firms, cf. Figure 2.8.

That firms with financial constraints are more likely to apply for SkatteFUNN than firms without such constraints, is a plausible explanation for the high share of non-taxable firms among SkatteFUNN beneficiaries. Cappelen et al. (2012) identifies a strong negative correlation between being tax liable and propensity to apply for SkatteFUNN and points out that *"(…) participation in SkatteFUNN is motivated by the liquidity situation of the firm: If the firm is not tax liable, the tax credit will be given as a grant and thus increases the firm's cash holdings. SkatteFUNN is more easily accessible source of cash than ordinary research grants, (…)*".

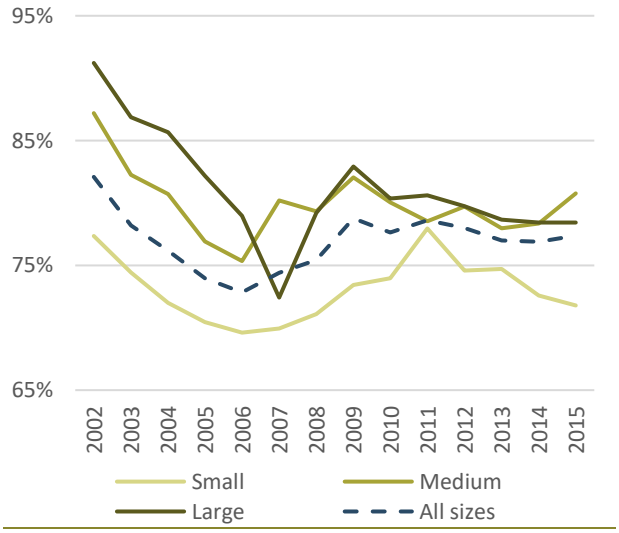
The development in the share of tax liable firms appears to be largely explained by the economic development, with some deviations. Since 2005 producer prices have risen significantly more than the historic trend, keeping firm revenues high. Higher revenues increase the share of tax liable firms. However, economic activity fell during the global financial crisis, reducing the share of tax liable beneficiaries between 2008 and 2011, before increasing in recent years, cf. figure 2.7.

Figure 2.7 Share of SkatteFUNN beneficiaries that are tax liable, by project size



Notes: Small projects are projects with total R&D costs below NOK 4 mill, medium with total costs between NOK 4 and 5.5 mill and large with total costs above NOK 5.5 mill

Figure 2.8 Share of the tax credit paid out as grants by project size



Notes: Small projects are projects with total R&D costs below NOK 4 mill, medium with total costs between NOK 4 and 5.5 mill and large with total costs above NOK 5.5 mill

[21] When the tax credit exceeds the firm's tax payable or if the firm is not in a tax position, i.e. have a tax liability of zero, the difference between the tax credit and the firm's tax payable (which is zero in the latter case) is paid out to the firm as a grant.

2.4 Characteristics of beneficiaries of SkatteFUNN

In the following we present what characterise beneficiaries of SkatteFUNN and whether these characteristics have changed with the changes in the scheme. To do this we have divided the data period in six regimes, corresponding to the main changes in the scheme; 2002-2003, 2004-2006[22], 2007-2008, 2009-2010, 2011-2013 and 2014-2015.

The descriptive statistics are based on data from the SkatteFUNN project database and a survey to 600 randomly selected beneficiaries of SkatteFUNN.[23]

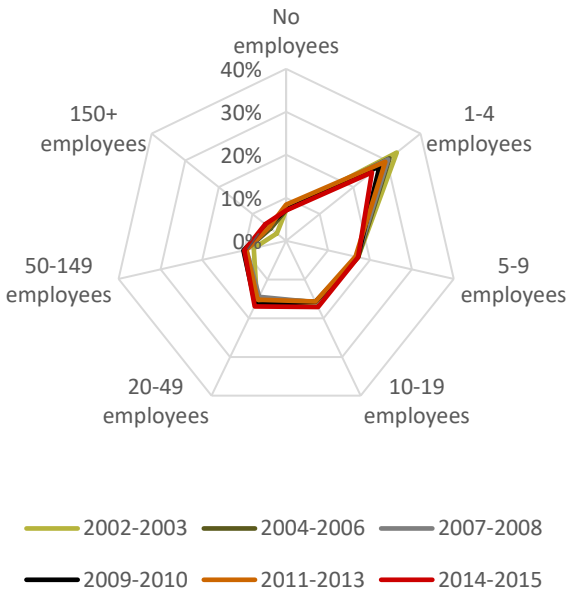
2.4.1 Firm size

About half of the beneficiaries of R&D tax credits are firms with less than 10 employees. However, among those who continuously use SkatteFUNN, the share of firms with less than 10 employees has decreased over time, cf. Figure 2.9. Given that the main share of beneficiaries each year are firms that continuously use the scheme, it is reasonable that firm size (and age) increases.

Among new applicants the share of firms with less than 10 employees have been relatively stable over time, cf. Figure 2.10. Furthermore, more than 80 per cent of new applicants, as well as the "regulars", are firms with less than 50 employees. Though the share of SkatteFUNN beneficiaries (both new and existing) with less than 50 employees (small firms) are somewhat lower than the corresponding share among Norwegian firms in general, it is fair to say that the scheme meets the objective of stimulating SMEs.

Of all non-financial firms (mainly consisting of limited liabilities), around 90 per cent are small firms. This is the same share as the share of small firms within manufacturing.

Figure 2.9 Firm size when receiving an R&D tax credit



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

Figure 2.10 Firm size first year with an R&D tax credit

Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

[22] There were no changes in the scheme in this period.

[23] The survey was conducted by Technopolis. For more details about the survey see Appendix A.

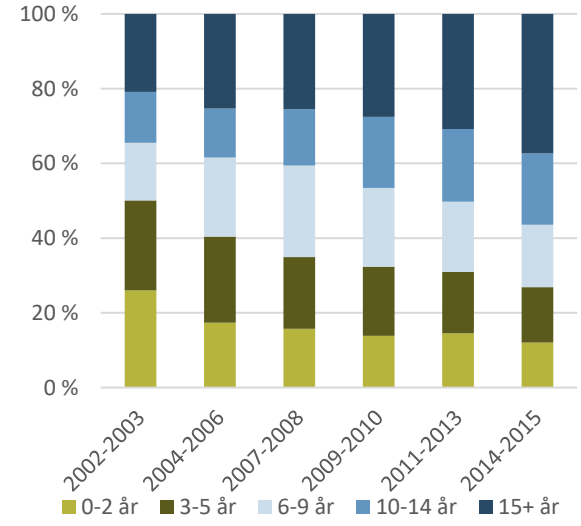
SkatteFUNN is to a much greater extent relevant for SMEs, compared to schemes with similar objectives, such as RCN's BIA.[24] About 44 per cent of project managers in BIA projects are firms with less than 50 employees, whereas only 22 per cent of these firms have less than 10 employees.

The annual R&D surveys conducted by Statistics Norway are sent to all firms with more than 50 employees, but only to a selection of firms with 10-50 employees. Thus, a significant share of beneficiaries of SkatteFUNN are not included in the statistics on firm's R&D expenditures. Challenges related to this issue are commented in more detail in chapter 4.

2.4.2 Firm age

Firms receiving an R&D tax credit has become more mature over time, cf. Figure 2.11. The main explanation for this is that new beneficiaries of SkatteFUNN only make up approximately 20 per cent of the beneficiaries each year. Thus, the main share of firms receiving an R&D tax credit are "regulars" and their age has naturally increased over time.

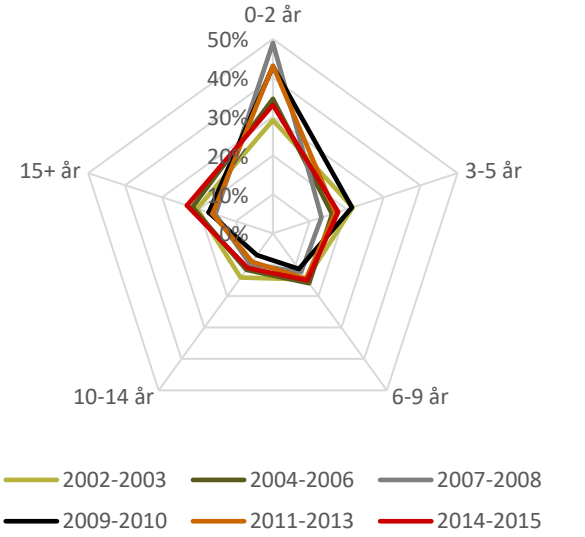
Figure 2.11 Firm age when receiving and R&D tax credit



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

Furthermore, the share of more mature firms among new beneficiaries of the scheme has increased over time, cf. figure 2.12. The increase in the share of mature firms is in line with the purpose of the last three changes in the scheme; increasing the limit for tax-deductible R&D expenditure to motivate larger firms to apply for an R&D tax credit. Larger firms are normally more mature firms.

Figure 2.12 Firm age first year with an R&D tax credit



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

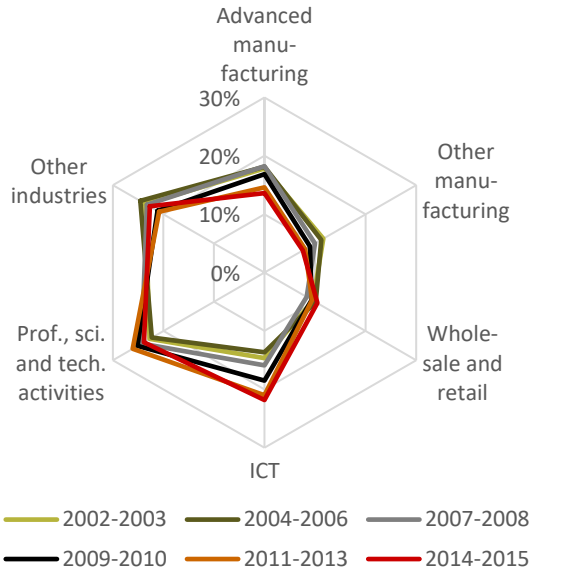
2.4.3 Industrial distribution

Measured in number of SkatteFUNN beneficiaries, three industries stand out; advanced manufacturing, ICT and professional, scientific and technical activities. ICT and professional, scientific and technical activities increased their share of total beneficiaries throughout the period between 2002 and 2015, cf. Figure 2.13. The share of manufacturing firms has decreased.[25]

[24] BIA stands for user-driven research-based Innovation. BIA funds industry-oriented research and has no thematic restrictions.

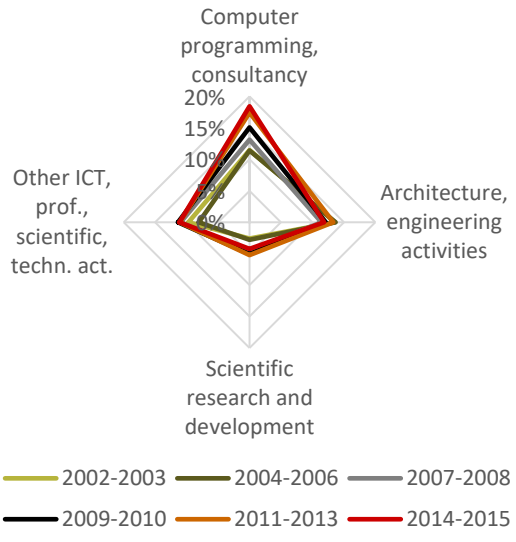
[25] It is worth noting that firms within wholesale are tightly linked to manufacturing industries such as wholesale of pharmaceutical products and wholesale of mining, construction and civil engineering machinery.

Figure 2.13 SkatteFUNN beneficiaries by industry. Share of total



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

Figure 2.14 SkatteFUNN beneficiaries by industry. ICT, professional, scientific and technical activities. Share of total.

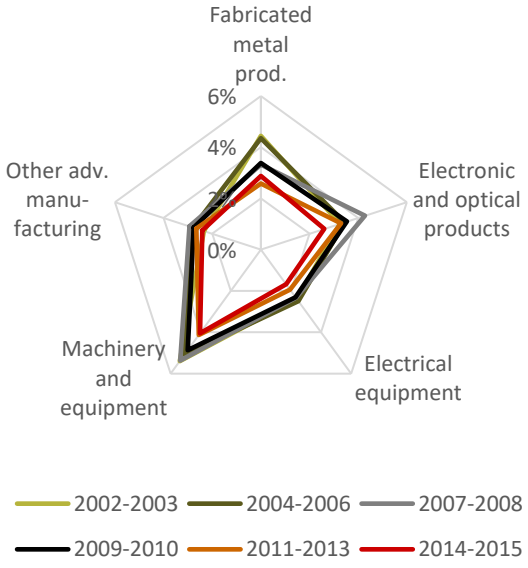


Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

It is computer programming and engineering activities that make up the largest share of the abovementioned growing industries, cf. Figure 2.14. Within advanced manufacturing, most firms receiving an R&D tax credit are manufacturers of machinery and equipment, fabricated metal products and electronic and optical products, cf. Figure 2.15.

Compared to the industrial distribution among beneficiaries of selected schemes with similar objectives, the industrial composition of firms using SkatteFUNN resembles that of Innovation Norway and Horizon 2020, e.g. approximately 20 per cent of beneficiaries of grants from Innovation Norway are firms within the ICT sector. This share is significantly lower among beneficiaries of comparable programs in RCN. In contrast, professional, scientific and technical activities make up a higher share of beneficiaries of support from RCN, Innovation Norway, regional research funds and Horizon 2020.[26]

Figure 2.15 SkatteFUNN beneficiaries by industry. Advanced manufacturing. Share of total.



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

[26] Comparisons are based on data in Samfunnsøkonomisk analyse ASs' database on beneficiaries from all Norwegian funding agencies.

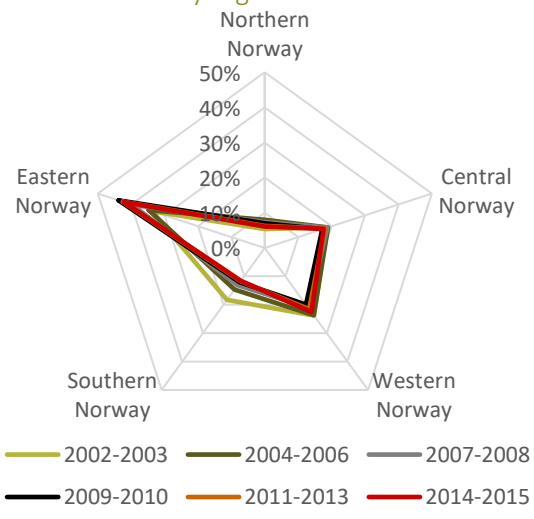
2.4.4 Geographical distribution

Almost half of all beneficiaries are located in Eastern Norway, and half of these in Oslo (cf. Figure 2.16).[27] The geographical distribution of beneficiaries of SkatteFUNN is almost identical to the distribution of firms receiving R&D grants from the RCN, whereas firms with support from Innovation Norway's schemes with comparable objectives have a somewhat different geographical distribution (Cappelen, et al., 2016).

Compared to the geographical distribution of all firms, the main discrepancy is the share of SkatteFUNN beneficiaries in Northern and Central Norway. About 10 per cent of all firms are located in Northern Norway, but only about 7 per cent of the beneficiaries (on average between 2002 and 2015).

Corresponding to the relatively low share of firms in Northern Norway, the share of SkatteFUNN firms in Central Norway is higher than among firms in general. This can be explained by the SkatteFUNN firms' industrial affiliation, the type of research supported by SkatteFUNN and the location of research institutions such as NTNU and SINTEF.

Figure 2.16 Firms by region



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

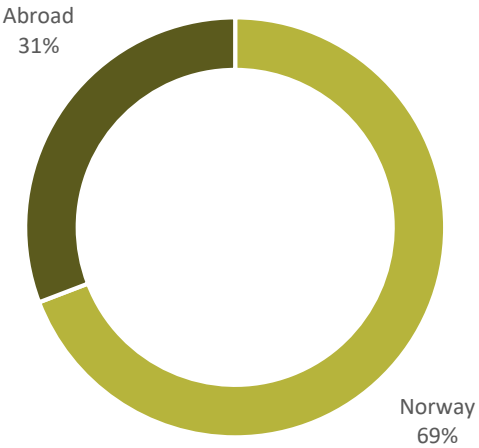
2.4.5 Customers of SkatteFUNN firms

Around two thirds of the respondents in our survey state that most of their customers are Norwegian, whereas the remaining firms mainly identify themselves as exporters, i.e. mainly selling their products to customers outside Norway, cf. Figure 2.17.

The share of exporters is higher among the smallest firms and among firms with several SkatteFUNN projects; among firms with six or more projects, 40 per cent state that they are exporting firms.

Almost four out of five firms (78 per cent) have most of their customers within the private sector, 13 per cent in the public sector and 3 per cent mainly have private consumers (cf. Figure 2.18). The remaining firms could not place their customers in either of the abovementioned categories.

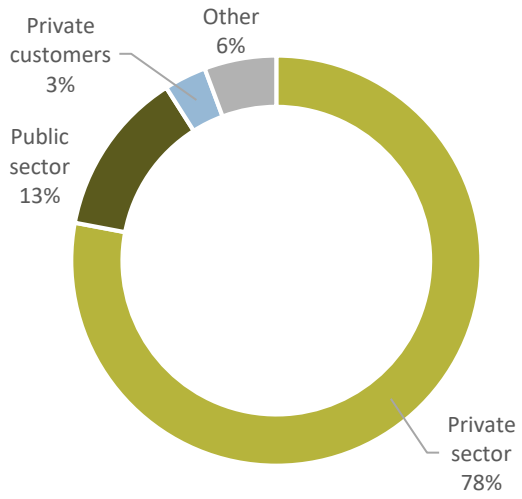
Figure 2.17 Origin of customers of SkatteFUNN firms. N=594.



Source: Technopolis' user survey

[27] In some cases, the R&D activity may be registered at the firm's head office, though it is carried out by a different unit of the corporation, with a different location than the head office. This is, however, probably not the case for most SkatteFUNN users; the geographical distribution corresponds with the geographical distribution of the industries represented by the users of the scheme.

Figure 2.18 Sectoral distribution of customers of SkatteFUNN firms. N=594



Source: Technopolis' user survey

2.4.6 Experience with R&D

Firms were asked to self-assess their level of R&D experience prior to the start of their first SkatteFUNN project. For our further analyses, we have grouped firms in three levels of "R&D maturity". The first category contains firms that reported that they had no prior experience with R&D and includes 22 per cent of the firms. The category "intermediate R&D maturity" comprises 51 per cent of firms, and includes firms that responded that they had:

- Experience of using openly available R&D results, or
- Experience of purchasing R&D services from an external supplier, or
- Experience of R&D performed in-house (intramural), or
- R&D as an integrated process for development of new products.

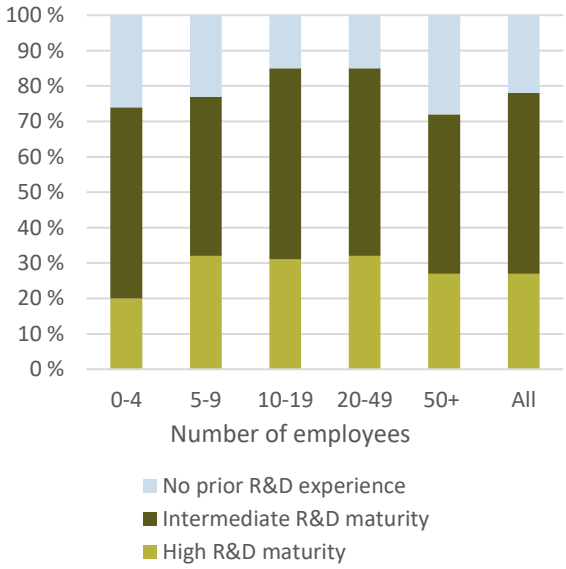
The third category of R&D maturity consist of firms which stated that "R&D was significant for the firm's business development and considered to create clear competitive and/or efficiency benefits", which we interpret as high R&D maturity; this category covers 27 per cent of the firms.

Among small firms (less than 50 employees), the R&D maturity increases with firm size, cf. Figure 2.19. The smallest and the largest firms (fewer than 5 or more than 49 employees) include the highest shares of firms with no experience of R&D prior to their first project. However, looking at the share of firms with no R&D in the last three-year period in the R&D surveys (see chapter 1.1), it is apparent that the share of R&D active firms increases with size, cf. Figure 2.20.

A slightly larger share of firms in manufacturing report a high degree of R&D maturity (31 per cent), compared to firms in other industries (27 per cent).

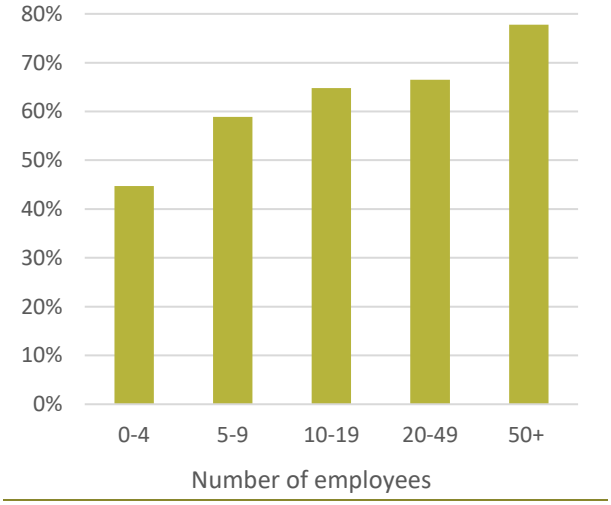
Furthermore, firms with more R&D experience are more likely to have had multiple SkatteFUNN projects.

Figure 2.19 Firm R&D maturity prior to first SkatteFUNN project. N=597



Source: Technopolis' user survey

Figure 2.20 Share of R&D active firms last three-year period



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

2.5 Administrative costs

The administrative costs of SkatteFUNN consist of the firms' and the government's costs. Firms incur costs when writing applications, preparing annual and final reports and providing control and certification of the project accounts. The government incurs costs of administrating the scheme in RCN and the Tax Administration.

The previous evaluation by Cappelen et al. (2008), estimated the firms' costs of applying and reporting to NOK 35 million for 2006. This was based on an average of 30 hours for the application and 10 hours for preparing the final report (cf. user surveys by Foyn and Lien, 2007).[28] An hourly rate of NOK 365 was used when estimating costs.

We apply the same average number of hours for completing 3651 applications and preparing the final reporting for 3028 approved projects in 2015. Furthermore, we apply an hourly rate of NOK 511 and calculate the firms' own costs to be NOK 71 million in 2015.[29] However, if the maximum hourly rate that applies to SkatteFUNN projects for 2015 is used (NOK 600), the costs increase to NOK 84 million.

In our user survey, about a third of the firms reported that they had used consultants to write their application. This share is unchanged from the previous user survey. Assuming that the same average amount of 4 hours is invoiced at an indexed hourly rate of NOK 1,400, this amounts to about NOK 7 million.

Auditing costs are estimated at NOK 21 million. This estimate is also uncertain, since there are large variations in how much time the auditors spend on each form. A survey conducted among auditors in the previous evaluation suggested that they spent on average 4 hours on each form and that the hourly rate was about NOK 1,250 (Cappelen, et al., 2008). We use the same number of hours and an indexed hourly rate of NOK 1,750 when calculating the auditing costs in 2015.

The firms' total costs amount to NOK 93 million, excluding consultancy costs and assuming an hourly rate of NOK 511 for the firms' use of time. This makes up about 3.5 per cent of the firms' total tax deductions in 2015, which is slightly lower than in the previous evaluation.

In addition to the firms' costs, the government also incurs costs administrating the scheme in RCN and the Tax Administration.

The SkatteFUNN secretary at RCN spent NOK 17 million for running the scheme in 2015 (according to their annual accounts).

The costs of the Tax Administration are more difficult to calculate, especially since the control efforts vary somewhat from year to year. The direct costs for tax

[28] Average of a total of 2,500 applications and 2,000 annual reports for approved projects. The costs per firm varied considerably.

[29] The hourly wage from 2006 is indexed by 1.4. Our calculations are based on the price index for wages for R&D personnel calculated from the official statistics. We apply this index to adjust all hourly rates used in the previous evaluation from 2006 to 2015 values if an exact value for 2015 is not available.

audits in 2015 were equal to three full-time equivalents (about NOK 2.25 million). Estimated costs for auditing and handling complaints in 2017-kroner are NOK 10.5 million, based on the use of 14 full-time equivalents.[30]

Some costs are also incurred by the Ministry of Finance and the Ministry of Trade, Industry and Fisheries. These were estimated by the Government Agency for Financial Management (SSØ) to be NOK 1.4 million in 2006. Adjusting by the price index we get an amount of about NOK 2 million in 2015.

The cost to all government agencies involved therefore amounted to about NOK 29 million in 2015 that is (in real terms) lower than in 2006.[31]

The above figures sum up to a total cost of approximately NOK 130 million for the firms and the public sector in 2015. This corresponds to almost 5 per cent of the total tax relief in 2015, which is lower than in the previous evaluation.[32] The administrative costs in the public sector alone correspond to only one per cent of the tax relief. This is very modest. Especially given, that we accounted for potentially more audit efforts by the tax authorities in 2015 than it was a case. The total estimated costs for the government is NOK 2,875 million in tax expenses and NOK 29 million in administrative costs, giving a total of NOK 2.9 billion. If we include a tax financing cost in the form of a 20 per cent efficiency loss (to account for the amount that needs to be financed from an increase in other taxes distorting the resource use in the economy), the public costs of the R&D tax credit scheme amount to NOK 3.5 billion for 2015.

[30] We expect that the Tax Administration will continue to spend at least as many resources for audits as in 2017, if not more, hence we use the latter, higher, amount when calculating the total administrative costs of SkatteFUNN.

[31] Before 2015 pre-qualification of SkatteFUNN applications was done by Innovation Norway. Since 2015 the entire process of project inspections has been concentrated at the Research Council of Norway leading in the sum to the lower government's costs.

[32] The previous evaluation estimated the total administrative costs to be equal about 7 per cent of the total tax relief in 2006, while Mohnen and Lokshin (2009) report that the total administrative costs are about 9 per cent of total support in both the Dutch and Canadian R&D tax credit schemes.

3 Public stimulus of R&D internationally

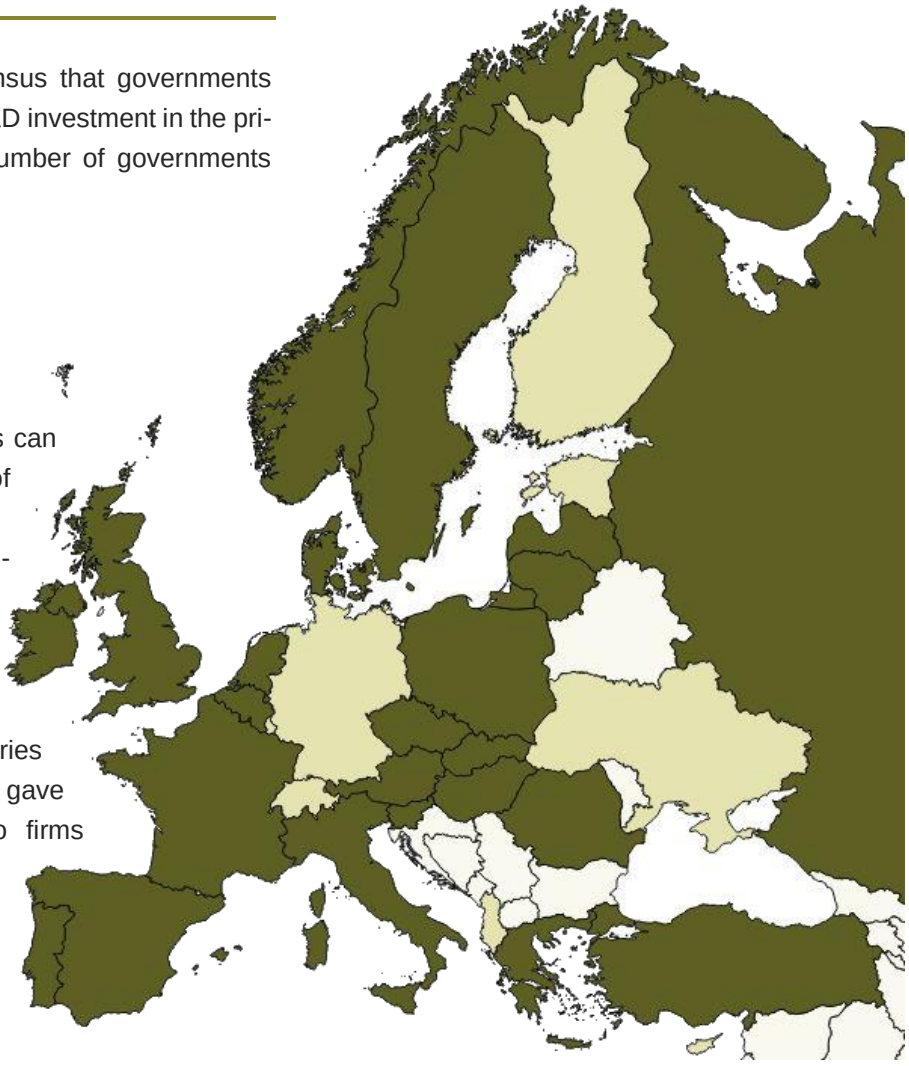
It is internationally agreed upon that governments have a role in encouraging R&D investment. R&D tax incentives are among the most popular innovation policy tools. In 2016, 29 of 35 OECD countries gave preferential tax treatment to firms with R&D expenditures. The majority of R&D tax incentives allow deduction of eligible R&D expenditure and several accredited schemes favour SMEs or young firms.

On average evaluation studies find that firms increase their R&D expenditure by more than the size of the tax credit. Although, that R&D tax incentives result in increased R&D expenditure seems to be consensus, the results on the effectiveness of R&D tax incentives on innovation is mixed.

Internationally, it is a consensus that governments have a role in encouraging R&D investment in the private sector. An increasing number of governments are therefore offering indirect support to increase spending on R&D through fiscal incentives. This can be in addition to or instead of direct support, for example through grants. R&D tax incentives are, internationally, among the most popular innovation policy tools.

In 2017, 30 of 35 OECD countries and 21 of 28 EU-countries gave preferential tax treatment to firms with R&D expenditures (OECD, 2017). The countries in Europe that had an R&D tax incentive in 2017 are shown as dark green on the map. The countries with a lighter shade of green did not have any R&D tax incentive at the time.

Essentially, the various schemes reduce taxes for firms that have R&D expenditure or income from commercialising intellectual property rights (IPR) (Straathof, et al., 2014). R&D tax incentives are typically considered indirect, as the choice of how to conduct R&D projects is left in the hands of the firm. Governments use tax incentives both as a tool to support broad R&D and as a targeted public policy to foster innovation by firms with specific characteristics, such as SMEs or firms specialising in energy and information systems.



Although all R&D tax incentives aim to increase R&D in the private sector, they vary greatly. Broadly, they can be separated into input- and output-related R&D tax incentives.

Input-related tax incentives decrease the cost of R&D inputs faced by firms, typically by reduced tax rates on social security taxes on R&D personnel or other R&D expenses.

Output-related R&D tax incentives increase the returns from innovative products that are protected by IPR. An example is patent boxes, under which income attributable to intellectual property developed through R&D is taxed at favourable rates.

In this chapter, we will compare the features of R&D tax incentives in selected countries. In general, the choice of R&D tax measure depends on country-specific variables, such as overall innovation performance and the nature of the corporate tax system. At the end of the chapter, we will go through evaluations of schemes in France, Austria, The Netherlands and the UK. These schemes were selected to provide an overview of a variety of schemes and their impact.

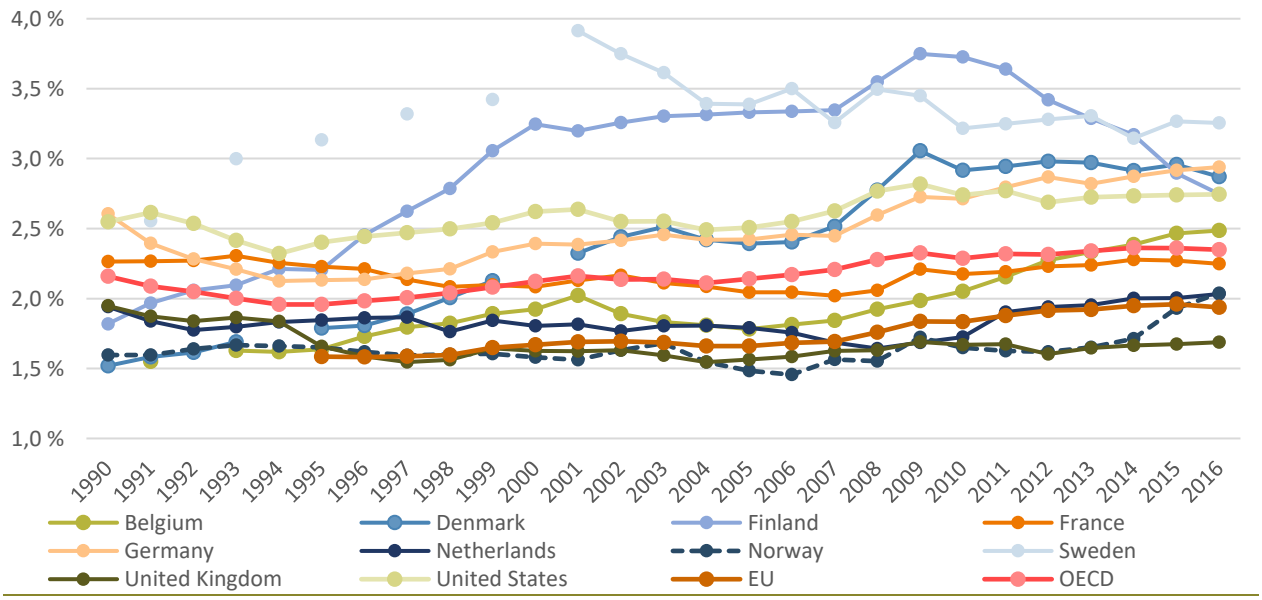
3.1 Spending on R&D varies across countries

Figure 3.1 illustrates the development of gross domestic spending on R&D as share of GDP for selected countries. The European Commission has set 3 per cent of GDP as an objective for each Member State's domestic spending on R&D, and of these 3 per cent, two-thirds should be financed by the private sector. Most countries do not meet this target.

Domestic spending on R&D varies between countries but has been increasing in most countries since the financial crisis in 2008-09. During recessions firms typically reduce their investment in R&D (Morbey & Dugal, 2016; Bernanke & Gertler, 1989; Mairesse, et al., 1999).

R&D investments are predominantly financed through firms' cash-flow, which tends to fluctuate procyclically with demand, hence we would expect procyclical R&D investment (Arvanitis & Woerter, 2013). However, the public support of R&D investment did increase significantly in most countries during the financial crisis. Therefore, a fall in R&D investments was avoided.

Figure 3.1 Share of gross domestic spending on R&D as a share of GDP



Source: OECD, Main Science and Technology Indicators

Figure 3.1 includes both public and private spending on R&D. It is interesting to note that our Nordic neighbours are among the biggest spenders on R&D in this selection of countries. This is even though Finland, Sweden and Denmark have relatively low governmental support of R&D in the private sector (Straathof, et al., 2014). Norwegian spending on R&D is at the lower range, with a share close to the Netherlands' and the UK's.

Even though R&D expenditure as a share of GDP has increased in most countries in recent years, the evolution of privately financed R&D is relatively stable in most countries.

When it comes to R&D tax incentives, only a few European countries do not have a tax policy aimed at stimulating R&D, cf. the map on the first page of this chapter. These are Germany, Finland, Moldova, Luxembourg, Cyprus, Switzerland, Albania, Bosnia & Herzegovina, Ukraine, Belarus, and Estonia. Of countries within the EU only Germany, Finland, Bulgaria and Estonia do not have an R&D tax incentive. Germany is, however, planning to implement such a scheme in 2019.

The main advantages of R&D tax incentives, relative to direct R&D funding, are often argued to be low administrative costs, simple application process and neutrality along several dimensions. The schemes typically do not target specific sectors or regions and firms can decide by themselves which projects to go for thus limiting distortive effects (Cunningham, Shapira, Edler, & Gok, 2016).

However, there are also some disadvantages. Firstly, R&D tax incentives increase the government's budgetary uncertainty. Secondly, there is a risk that a certain share of the R&D activities would have been carried out irrespective of the scheme. Thirdly, as a consequence of low administrative costs and a simple application process, the potential for misuse is typically higher than for more demanding R&D incentives.

The presence and extent of such advantages and disadvantages depend on the design of the scheme. In chapter 3.2, we elaborate upon different schemes.

3.2 Cross-country comparison of R&D tax incentives

A comparison across countries is challenging due to the diversity of schemes. However, most explicitly target costs of activities related to R&D, and often in particular costs related to R&D personnel.

Furthermore, tax credits are the most common R&D tax incentive, followed by allowances offset against income and accelerated depreciation for fixed assets used in R&D projects (Straathof, et al., 2014). Many countries also have patent boxes. Most tax incentives are linked to taxes on corporate income, whereas some are to social security contribution.

3.2.1 Most of R&D tax incentives are volume-based

The majority of R&D tax incentives allow deduction of eligible R&D expenditure (volume-based schemes). A few schemes apply only to increases in R&D expenditure, for example over a year (incremental schemes).

Incremental schemes were the initial choice of several countries for two reasons (Cunningham, Shapira, Edler, & Gok, 2016). Firstly, the main objective for public R&D support is to *increase* R&D, rather than to provide recurring support for existing R&D activities. It was therefore argued by Cunningham et al. (2016) that an incremental scheme is the most efficient to reach the objective. Secondly, it is arguably easier to identify and avoid misuse of the scheme if it is incremental. With a system based on increased R&D expenditure, and not total volume, it

is not possible over the long term to over- or underestimate R&D expenditure. Despite these arguments, incremental schemes are considered too complex, which is why most countries have moved towards volume-based schemes.

The generosity of the schemes varies, both when it comes to the percentage of R&D expenditure that can be deducted and the maximum (and minimum) amount that can be claimed. The percentage of R&D expenditure that can be deducted from the tax burden with the headline R&D tax credit rate varying from 10 per cent in Italy, 12 per cent in Austria, 18 per cent in the Netherlands, 20 per cent in Norway, to close to 30 per cent in Spain and France (Cunningham, et al., 2016).

When it comes to R&D tax allowances, governments determine a multiplier for R&D expenditure that can be deducted from taxable income. In the UK the multiplier is 130 per cent.

Regarding a maximum amount of tax reduction that can be claimed, several countries have implemented a cap, as with SkatteFUNN, whereas others do not have a limit, for example Austria. The cap can either be an absolute ceiling or a threshold where the tax rate changes for expenditure above the limit.

Some countries have schemes with a minimum project size as the basis of tax reduction, rather than a maximum. The rationale for having a minimum threshold is to avoid disproportionate administration and compliance costs. In Australia, the firm must incur R&D expenses of at least AUD 20,000 to be eligible for tax credit (OECD, 2017).[33] SMEs engaged in R&D are eligible for a 43.5 per cent tax credit, whereas large firms are eligible for a 38.5 per cent non-refundable tax credit (entities may be able to carry forward unused offset amounts to future income years). In New Zealand it was recently suggested to implement a minimum of NZD 100,000 spent on eligible R&D expenditure within one year to qualify for the R&D tax incentive (The New Zealand Government, 2018).[34] The argument for setting the minimum at NZD 100,000 of eligible expenditure is mainly to filter out claims that are not likely to be genuine R&D and to reduce the administrative costs of the scheme. An additional argument is that a lower limit might enhance collaboration between firms, as the cost of the project may be too large for a single firm.

3.2.2 R&D tax incentives may be general or favour certain characteristics

While tax incentives are essentially a general policy instrument, targeting specific groups of firms is quite common. The generosity of R&D tax incentives is inherently linked to the design of tax incentives as well as firm characteristics.

The schemes often differentiate their level of generosity by type of firm, type of R&D activity, region or sector. For example, some countries, like Norway, have different tax deduction rates depending on the size of the firm, whereas others have different rates depending on the scope of the firm's R&D expenditure.

In this section the main characteristics of schemes are presented.

Targeting size and profitability

There is a significant variation in the generosity of R&D tax incentives for firms of different size and profitability.

The rationale behind the support is typically to alleviate difficulties to increase R&D investment, which

[33] The scheme also includes a maximum cap of $ 100 million of R&D expenditure each year.
[34] The scheme also includes a maximum cap of $120 million of R&D expenditure each year. The minimum threshold will not apply to R&D activities outsourced to an Approved Research Provider.

is more prevalent for SMEs and start-ups. Therefore, it is common for the tax credit schemes to target SMEs and/or young firms, by offering them more generous tax advantages. The Netherlands and the UK are examples of countries, other than Norway, whose R&D tax incentives favour SMEs.

Tax credit schemes can apply to firms that make a profit in the same year as the R&D expenditure, or there can be options to carry tax credits backward or forward. Such features offer firms more flexibility and certainty in investment decisions. Loss making firms will get the option of not surrendering the R&D loss but instead carrying the loss forward/backwards against profits.

Another option, which is included in SkatteFUNN, is that claims can be disbursed even if the firm has insufficient taxable income to use their tax credits. An example is Skattekreditordningen in Denmark, which was implemented as a counter-cyclical measure to combat the economic recession (Straathof, et al., 2014). The scheme targets R&D expenses of loss-making firms. A similar scheme was implemented as a counter-cyclical measure in France as well. The scheme in New Zealand also provides a tax credit for firms in a tax loss position (Deloitte, 2017). Indirectly, such an approach shifts the support to young and small firms. The idea was that the disbursements would particularly strengthen the liquidity of SMEs in the start-up phase, before R&D activities resulted in income.

Figure 3.2 illustrates how the tax subsidy rates on R&D expenditure varies between countries and by firm size and profitability. The higher the tax subsidy rate, the more favourable the scheme. The tax subsidy rates on R&D expenditure is measured as one minus the B index.[35]

Algebraically, the tax subsidy rate is defined as:

$$\tau = 1 - \frac{1 - A}{1 - t}$$

Where τ is the tax subsidy rate, $1 - A$ is the after-tax cost of spending on R&D, and t is the corporate income tax rate. The after-tax cost is the net cost of investing in R&D, considering all the available tax incentives.[36]

The OECD median tax subsidy rate is estimated to 0.19 for profitable and to 0.13 for loss-making SMEs, above the OECD median of 0.13 for large profitable firms and of 0.10 for large loss-making firms (OECD, 2016). This result is attributable to the preferential tax treatment that 12 of 28 OECD countries currently provide for SMEs and/or young firms vis-à-vis large firms.[37]

Taking France (FRA) as an example, the tax subsidy rate of 0.43 for the SME segment tells us that the marginal cost of investing in R&D is 57 per cent of the cost of regular investment. Equally, it tells us that the firm receives € 0.43 for R&D expenditures of € 1.

The difference between the tax incentives in these countries can be analysed by comparing the lines and diamonds in the figure. When the dark blue diamond is showing a higher tax subsidy rate than the

[35] The B index is a tool for comparing the generosity of the tax treatment of R&D in different countries. Algebraically, the B index is equal to the after-tax cost of spending on R&D divided by one minus the corporate income tax rate. The after-tax cost is the net cost of investing in R&D, considering all the available tax incentives. The more favorable a country's tax treatment of R&D, the lower its B index. The computation of the B index requires some simplifying assumptions. Its "-synthetic" nature does not allow for distinguishing the relative importance of the various policy tools it considers (*e.g.* depreciation allowances, special R&D allowances, tax credit, CITR). Some detailed features of R&D tax schemes (*e.g.* refunding, carry-back and carry-forward of unused tax credit, or flow-through mechanisms) are for example not considered. Model is confined to tax measures related specifically to the R&D decision at the corporate level. Some countries may offer no R&D tax incentives but compensate for this by taxing investment income very lightly. The B index should therefore be examined together with a set of other relevant policy indicators.

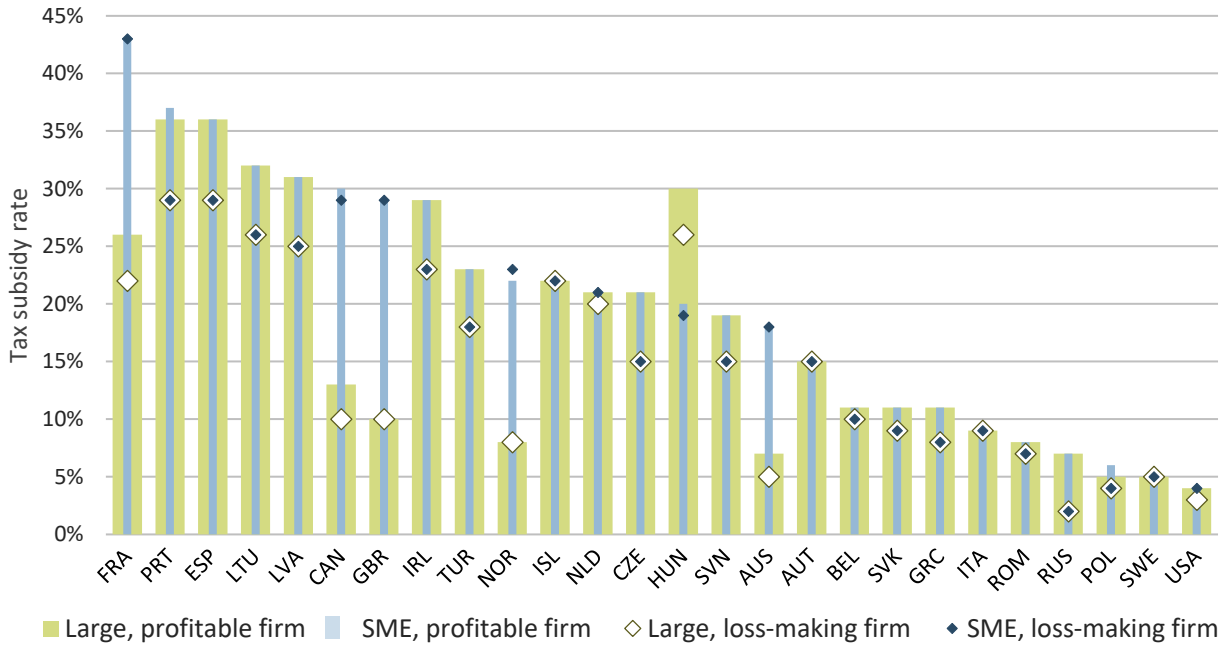
[36] If a country does not have an R&D tax incentive, the B index is at least one, and the tax subsidy rate is zero or negative.

[37] The only country who provides preferential tax treatment to larger firms is Hungary.

white diamond, it means that the country's R&D tax incentive(s) favour SMEs to large firms. In 2016, France (FRA), Portugal (PRT) and Spain (ESP) had the highest tax subsidy rates for SMEs, in both the profit-making and loss-making scenarios.

Figure 3.2 illustrate that tax incentives often are more generous for SMEs and/or young firms than for large firms. This is the case for France, Norway (NOR), Canada (CAN), Australia (AUS) and Great Britain (GBR).

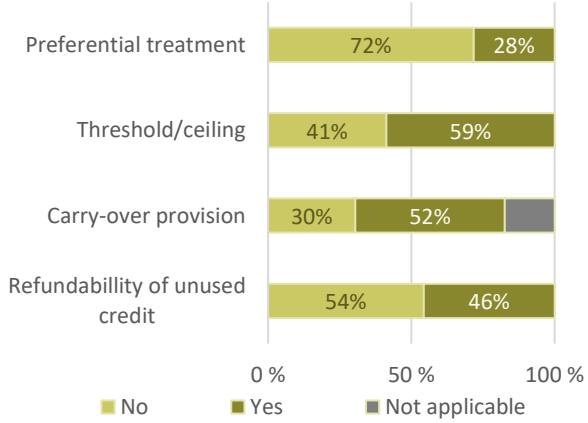
Figure 3.2 Tax subsidy per € of R&D expenditures for selected OECD countries, by firm size and profit scenario in 2016.



Source: OECD, 2016

Figure 3.3 illustrates that 28 per cent of R&D tax incentives does have preferential treatment based on firm characteristics, typically preferential treatment of SMEs. Close to 60 per cent of schemes have ceilings or limits, typically related to the amount spent on R&D. Furthermore, 52 per cent of the schemes offer carry-over provisions to make planning of investment expenditure easier for firms. 46 per cent have an option of refundability of unused credit, such as SkatteFUNN.

Figure 3.3 Share of schemes subject to relevant provisions



Source: OECD, Measuring R&D Tax Incentives, 2016

Variation related to legal status, sectors and collaboration

In contrast to SkatteFUNN, some countries, for example Sweden, Austria and the Netherlands, target the firm's legal status. The R&D tax incentive can for example be less generous for foreign-owned firms.

Some schemes also differentiate between sectors or industries, typically favouring sectors that are considered of strategic importance or having economic difficulties (Cunningham, et al., 2016). According to EU State aid law, it is not legal to target specific sectors with R&D tax incentives. However, it is possible to target specific fields of R&D, such as green technology – which is favoured in Belgium. Under such a design, the scheme becomes more complex and might cause distortions in the sense that firms might have an incentive to adapt their activity to be eligible for the scheme.

Collaborative R&D are also often supported by tax incentives. This is because basic research is assumed to be associated with a potential for large external benefits.

3.2.3 SkatteFUNN in a Nordic perspective

Among the Nordic countries, Denmark, Iceland and Norway have volume-based tax credits redeemable against corporate income taxes, whereas Sweden's tax relief is redeemable against social security contribution expenses. The Finnish R&D tax allowance was discontinued in 2015, after having been in force for only a short period.

Sweden offers an R&D tax incentive in the form of a reduction of the social security contribution of employees engaged in R&D projects. Straathof et al. (2014) argues that Sweden appears to have the most 'unique' R&D tax incentive system, as it does not match with any other one country.

Denmark offer two R&D tax incentive instruments; tax credits including enhanced allowance, and accelerated depreciation on R&D capital. The tax incentives account for about 60 per cent of total public support of firm R&D. Firms in Denmark have been able to deduct their R&D capital expenditure in full in the year of acquisition of R&D capital (e.g. machinery and equipment) since 1973. Straathof et al. (2014) highlight the accelerated depreciation scheme as particularly good, due to its organisational practice and that it does not target specific groups of firms.

Skattekreditordningen in Denmark was implemented as a counter-cyclical measure to combat the economic recession by compensating firms for a temporary lack of external finance (Straathof, et al., 2014). The scheme targets R&D expenses of loss-making firms and provides options of carrying losses or gains forward or cash refunds.

The Finnish R&D tax incentive was intended as temporary from the outset and was abolished because an evaluation found that the scheme failed to reach its objective (Kuusi, Pajarinen, Rouvinen, & Valkonen, 2016). The scheme enabled firms a corporate tax deduction on labour expenses incurred when undertaking eligible R&D activities.[38]

Kuusi et al. (2016) explain that the utilisation of the scheme by Finnish firms were limited. The claimed deduction was very low, and the forgone tax revenue just eight per cent of what was expected by the authorities. Seemingly, loss-making firms were not interested in using the deduction even though carry forward of losses due to increased R&D was possi-

[38] The tax credit could be applied for new projects, and the project-specific deduction was 15,000 to 400,000 euros. The incentive excluded the use of other subsidies. The tax deduction could be carried over into future tax years.

ble. The liquidity concern could have been assessed by designing a subsidy allowing an immediate reduction of R&D labour costs, as in Sweden, or a negative tax as in Norway and Denmark. In Finland, benefitting from the subsidy was conditional on future profitability.

Kuusi et. al. (2016) concluded that the R&D tax incentive failed as a supplement to the Finnish, mainly subsidy-based, innovation system and that the impact remained rather small. Furthermore, firms receiving direct subsidies reported to a larger extent, that they had commenced new or expanded their existing R&D activities.

Kuusi et al. (2016) further concluded that the magnitude of the scheme should have been much larger to achieve a tangible effect on economic growth. As a policy experiment, the scheme was also criticised for not providing test conditions that allowed a rigorous, econometric analysis of its impacts.

Table 3.1 summarizes the characteristics of the R&D tax incentives in the Nordic countries.

Table 3.1 Overview of R&D tax incentives in selected Nordic countries

	Norway	Sweden	Finland	Denmark
R&D tax incentive	*SkatteFUNN*	*Skatteincitament för FoU*	*Corporate R&D Tax Relief*	*Skattekreditordningen*
Type of scheme	R&D tax credit	SSC reduction	R&D tax credit (Abolished)	R&D tax credit for loss-making firms
Eligible base	Volume of R&D tax expenditure	Labour cost	Volume of R&D tax expenditure	Volume of R&D tax expenditure
Differentiation between SME and large firms	Yes. 20 per cent tax deduction for SMEs, and 18 per cent for large firms.	No. 10 per cent deduction for all firms.	No. 100 per cent tax deduction for all firms.	No. 22 per cent tax deduction for all firms.
Ceilings	€ 10 million cap per year. € 12 million cap for R&D subcontracted to approved public research organisations.	SSC deductions capped at SEK 230,000 per month and firm. The resulting SSC must be at least equal to the old age pension contribution.	€ 400,000 cap in terms of eligible amount of R&D.	R&D expenditure ceiling at DKK 25 million. Maximum tax credit that can be given is DKK 5.5 million (22% of DKK 25 million).
Refund/ carry over	Yes, refund for firms that are not tax liable	Yes, immediate refund. No carry over.	Refund not applicable. No carry-forward, 10 years carry-back.	Immediate refund for all firms. No carry over.
Eligible firms	Available to all firms registered in Norway	Not available for self-employed, partners in a trading partnership and public employers.	All limited liability firms and collaboratives.	Corporations and self-employed with deficit related R&D expenses.

3.3 Evaluations of foreign schemes

The rising popularity of R&D tax incentives has been accompanied by a surge in the number of studies finding strong correlations between R&D tax incentives and increased R&D spending in the private sector.[39] Although it seems to be broadly agreed upon that R&D tax incentives result in increased R&D expenditure, prior empirical research has yielded mixed results on the effectiveness of R&D tax incentives on innovation.

[39] See for example Hall & Van Reenen (2000).

Throughout the remainder of this chapter, we will go through the main approaches for evaluating tax incentives and the main conclusions from the most relevant evaluations. They were selected to provide a broad overview of the variety of schemes. Furthermore, tax incentives from a selection of particularly relevant countries will be presented more thoroughly. These reviews will go through the main characteristics of the schemes and the major findings of the impact evaluations.

3.3.1 Evaluating of R&D tax incentives – alternative approaches

Comparing the effectiveness of R&D tax incentives between countries is a challenging task. Most R&D tax incentives have not been evaluated quantitatively, making it impossible to compare them directly. However, the relatively recent availability of high quality registry-based data, have enabled more precise evaluation of the impact of tax incentives (Guceri & Liu, 2017). It is important to note that, even if a scheme has been thoroughly evaluated, the results are not necessarily externally valid due to differences in framework conditions (Straathof, et al., 2014).

Quantitative evaluations of R&D tax credit schemes typically utilise two main approaches that both predict input additionality through different firm-, time- and location-specific factors. A few studies also estimate the output additionality, i.e. the schemes' actual impact on innovation.

Input additionality is defined as the firms' additional R&D investment that can be attributed to the policy intervention relative to the size of the tax credit itself. The difference between the approaches lies in which variables are used to measure the presence of the scheme. Each approach has its own set of assumptions, on which the demand for R&D is based. Each approach also has its own econometric challenges.

The first approach evaluates the input additionality by assessing the elasticity of R&D expenditure with respect to the user cost of R&D capital. The elasticity measures the firm's response to changes in a price index of R&D inputs. The user cost of capital can be defined as the actual cost of R&D faced by firms, where an R&D tax incentive is one of the determinants. The wage rate of researchers and the price of equipment are other determinants (Hall and Van Reenen, 2000). If a firm spends everything it saves on taxes on R&D expenditure, the input additionality is equal to one; if the firm spends more than it receives as a tax credit, input additionality is larger than one, and vice versa.

In the second approach, the impact of the tax incentive is estimated by comparing firms who were beneficiaries of the scheme with similar firms who did not use the scheme. Comparing the two groups makes it possible to create a counterfactual development, which will make it possible to separate the impact of the tax incentive. The estimated coefficient on the tax incentive usually can be directly interpreted as the input additionality of the scheme.

Whether tax incentives are efficient as R&D policy ultimately depends on how many innovative products and production processes they induce, not on whether R&D expenses increase. The output additionality is therefore of greater importance than the input additionality. Unfortunately, the causal impact of R&D tax incentives on innovation and productivity has rarely been studied. The limited knowledge that exists seems to point towards a positive impact on innovation.

3.3.2 Main conclusions of evaluation studies

Irrespective of approach, most evaluations of R&D tax incentives conclude that they are effective in stimulating investment in R&D (Straathof, et al., 2014). On average the studies find that firms increase their R&D expenditure by more than the tax

credit (Hall & Van Reenen, 2000; Arundel, Bordoy, Mohnen, & Smith, 2008).

Several econometric studies have found that one euro of foregone tax revenue on R&D tax credits raises R&D expenditure by about one euro (Hall & Van Reenen, 2000; Mairesse, Mohnen, Simpson, & Warda, 2008; Lokshin & Mohnen, 2012; Mulkay & Mairesse, 2013; Bloom, Griffith, & Van Reenen, 2002). This implies that the input additionality is about one.

However, the impact estimates vary widely and are not always comparable across countries due to differences in the schemes and the applied methodology (Straathof, et al., 2014; Köhler, Laredo, & Rammer, 2012; Ientile & Mairesse, 2009).

In addition, the meta-analysis by Gaillard-Ladinska, Nonand Straathof (2014) shows that reported estimates are often inflated substantially due to publication selection bias (the consequence of choosing research papers for the statistical significance of their findings). When accounting for this bias, the effect on R&D expenditure is positive but modest.

Only a few studies have tried to estimate the output additionality. In addition to the previous evaluation of SkatteFUNN, Cappelen et al. (2007), Czarnitzki, Hanel, and Rosa (2011) found a significant impact of the Canadian R&D tax credit on innovation.

The effect of R&D tax incentives on R&D expenditure varies across sub-groups of firms, with most studies focusing on firm size. In some of the countries analysed, SMEs seem to respond more strongly to the support, while the reverse has been found in other countries. There is some evidence that the impact for start-up firms can exceed the average impact. These seemingly contradictory results make it difficult to draw any clear conclusions.

Lokshin and Mohnen (2008) and Hall and Van Reenen (2000) note that even though it is important to estimate expenditure on R&D per euro in forgone tax revenue, this does not replace social cost-benefit analysis. Even if the increase in R&D expenditure per forgone tax revenue is below one, the scheme may still generate higher welfare due to positive spillover effects.

Recent evidence suggests that knowledge spillovers of large firms exceed those of small firms (Straathof, et al., 2014). This finding weakens the case for targeting tax incentives towards SMEs. On the other hand, SMEs increase their R&D expenditure more strongly in response to incentives.

Recommended characteristics of schemes

The impact of R&D tax incentives is highly sensitive to their design and organisation, as well as other national characteristics. However, thorough empirical studies are scarce.

One aspect that is relatively well studied, is the efficiency of incremental and volume-based schemes. Both have been found to result in additional R&D expenditure. However, Straathof et al. (2014) concluded that volume-based schemes are more effective than incremental ones. Incremental schemes may more effectively trigger additional, new research, but they may also trigger firms to change the timing of their R&D investment and may result in higher administrative and compliance costs.

As incremental schemes have not been found to stimulate R&D more effectively than volume-based schemes, the higher costs of incremental schemes suggest that volume-based are to be preferred. This supports that, and may also explain why, most schemes are volume-based. Furthermore, Köhler et al. (2012) conclude that volume-based incentives appear to have the largest effect on R&D expenditure, i.e. input additionality.

Another argument by Straathof et al. (2014) is that R&D tax incentives ideally should apply to the types of expenditures that bring about the largest knowledge spillovers. Schemes based on personnel costs for researchers can be considered best practice in this context, mainly because researchers move from one employer to another, spreading knowledge. Tax credits for researcher wages can for example be found in The Netherlands, Sweden and Belgium (Straathof et al., 2014).

Furthermore, Straathof et al. (2014) recommend that tax incentives target young SMEs, rather than SMEs in general. This assumes that young firms are more likely to be innovative. In France, there is implemented an R&D tax incentive that explicitly targets young firms and is referred to as best practice.

Straathof et al. (2014) point out that R&D expenditure may precede revenue generated by innovation by several years. Therefore, it is viewed as good practice to provide a carry-over facility and an option to receive the benefit even if a firm is not profitable. Such features offer firms more flexibility and certainty in investment decisions. This is especially relevant for young firms that typically are not profitable in their first years of operation. While most of the R&D tax incentives analysed have a carry-over facility, cash refunds are available only in nine countries, including in Norway.

The second highest ranking tax incentive in the European Commission's study is SkatteFUNN. This is mainly due to the non-bureaucratic and generic design of the scheme. SkatteFUNN is praised for having a one-stop, online application procedure.

In addition, SkatteFUNN's enhancement of collaboration between public research institutes and private firms is highlighted as an important characteristic. Collaboration between the private sector and research institutes often creates external benefits (Dumont, 2013).

3.3.3 Summary of schemes in selected countries

This chapter will go through the main characteristics of schemes and findings of impact evaluations in selected countries.

The French tax credit scheme for young innovative firms is included because it is ranked the highest in the European Commission's comparison of 80 different R&D tax incentives. It provides a generous tax credit to young SMEs whose R&D expenditure represents at least 15 per cent of their total costs.

The tax incentives in the Netherlands are also included as an example of good practice. The accreditation stems from their general character, wide scope of eligible types of R&D expenditure, and efficient administration. Furthermore, a special preferential rate is offered to young firms. Moreover, firms that do not make profits can still enjoy the benefit, further enabling young firms.

Although Austria spends a larger share of GDP on R&D than Norway, it is comparable to Norway both in size of the economy, tax system and in the tax incentive for R&D. Furthermore, the scheme was recently evaluated.

United Kingdom's R&D tax incentives, like Norway's, have different headline rates for SMEs and large firms. Another similarity is relative simplicity and easy application procedures. Firms have easy access to necessary information about the instrument's design, changes made and prospected, as well as practical information about application procedure and possible enquiries that may be made.

Table 3.2 summarise the characteristics of the R&D tax incentives in the different countries.

Table 3.2 Overview of R&D tax incentives in selected European countries

	France		The Netherlands	Austria	UK	
R&D tax incentive	*Crédit d'Impôt Recherche (CIR)*	*Le régime de la jeune entreprise innovante (J.E.I.)*	*Wet Bevordering Speur- & Ontwikkelingswerk (WBSO)*	*Research Premium (Forschungsprämie)*	*Corporate tax credit for R&D*	*R&D expenditure credit (RDEC) scheme*
Type of scheme	R&D tax credit	SSC reduction	R&D tax credit & SSC reduction	R&D tax credit	R&D tax credit	R&D tax credit
Eligible base	Volume of R&D tax expenditure	Labour cost	Volume of R&D tax expenditure and labour cost	Volume of R&D tax expenditure	Volume of R&D tax expenditure	Volume of R&D tax expenditure
Differentiation between SME and large firms	No. 30% headline tax credit rate, and 50% for firms in French overseas territories with R&D expenses up to €100 million, 5% for R&D expenses over €100 million.	Yes. 100% for SME, and no exemption for large firms. The exemption from SSC is available for 8 years for firms holds the JEI status.	No. 32% for eligible R&D costs up to € 350k, 16per cent above € 350k	No. 12% deduction.	Yes. 30% for large firms. 130% for SME.	Yes. 11% for large firms. Not applicable for SME.
Ceilings	€ 10 million cap per year. € 12 million cap for subcontractions to approved public research organisations.	4.5 times the minimum salary or 5 times the annual social security ceiling (€ 187,740 in 2014).		Subcontracted research expenditures are limited to € 1 million.	SME: Upper limit of €7.5 million per R&D project. No limit for large firms.	None.
Refund/ carry over	Large firms' claim may be used to pay income tax in the following three years. Immediate refund for SMEs.	Immediate refund to SMEs. Large firms not eligible.	Immediate refund for all firms. Carry-forward 1 year.	Immediate refund for all firms. No carry over.	Immediate for SME. Indefinite carry-forward, no carry-back.	Immediate refund. Indefinite carry-forward.
Eligible firms	Available to all tax liable French and foreign firms with R&D expenditures.	Less than 8 years old SMEs dedicating at least 15% of expenses to R&D (establishment must not be a result of restructuring).	All Dutch firms and self-employed entrepreneurs carrying out R&D projects. Public knowledge institutes are not eligible.	Any tax liable firm carrying out R&D activities within Austria or contracting it out to third parties within EEA.	All SMEs	All large firms

The French R&D tax incentive favours young firms

Investment in R&D is one of the top priorities of French economic policy. Still, R&D in the private sector is relatively low and stable. This primarily reflects the sectoral composition of the economy, where high-tech manufacturing sectors represent only a modest share. This is also the result of an insufficient engagement of firms of intermediate size in R&D activities (European Commission, 2013).

Although, spending on R&D in the private sector has not changed remarkably since the mid-2000s, the scope of R&D tax credits has increased. The increase is in particular due to the implementation of a more generous regime of tax credits in 2008. This was the first major change in generosity since 1983, when CIR (Crédit d'Impôt Recherche) was implemented. The CIR scheme was initially incremental but turned partly into a volume-based scheme in 2004. In 2008, the CIR scheme was made completely volume-based.

The reform in 2004 also consisted of the implementation of the volume-based *Young Innovative Firms Program* (JEI, "Jeunes Entreprises Innovantes"). Young innovative enterprises (JEI) and young university enterprises (JEU) can accumulate the JEI/JEU status with the research tax credit (CIR) (OECD, 2017). Virtually all R&D performers in France now use the CIR. The JEI scheme is viewed as best practice by the European Commission (Straathof, et al., 2014).

JEI targets young innovative firms defined as independent SMEs. The firms must be younger than eight years and their R&D expenditure must amount to at least 15 per cent of their total expenses.

The scheme avoids some possible unwanted tax adjustments, as firms that have been created because of restructuration of others (that would not qualify as JEI), or that are formed as an extension of existing firms, are not eligible for tax deduction.

The scheme is non-discriminatory in terms of sectors and geography. Firms can also receive an immediate refund and benefit from the scheme, even if they do not make a profit.

The scheme offers a wide range of different tax breaks, including reduced corporate and local taxes, as well as social security contributions.[40] A maximum amount that a firm can receive was introduced in 2011.[41] From January 2012, the first year of participation in the scheme gives exemption from corporate income taxes. In the second year, firms receive a 50 per cent reduction in the corporate tax. Starting from the third year, no corporate tax discount is given.

The rate of benefit available from social contributions was increased in 2012, offering firms to be exempt from the contributions in the first four years, and then gradually decreasing to a 50 per cent discount. The ceiling of the benefit per establishment was also increased to five times the amount of the annual social security contributions.

Starting January 2014, the rate of benefit for social security contributions was further increased. Qualifying firms are now exempt from social security contributions for the whole eight-year period. Furthermore, by decision of local authorities, firms having

[40] Since its introduction, the offered rates of discount have been amended various times. Up till the end of 2010, firms were exempt of social security contributions for the first eight years of JEI participation, and from corporate tax liability for the first three years. In the fourth and fifth year it offered a 50 per cent reduction in the corporate tax rate. In 2011, the social security contribution benefits were decreased, offering tax exemption in the first four years, and then gradually decreasing to 10 per cent discount.

[41] This implies that the benefit cannot exceed € 200,000 over three fiscal years. Per salary the maximum amount that can be received is 4.5 times the minimum salary; per establishment - three times the ceilings of social security contributions, being € 106,056 in 2011.

JEI status may be exempted from property tax on buildings and territorial economic contributions for seven years.

The qualifying R&D activities are defined according to OECD's Frascati Manual that includes basic and applied R&D.[42] According to the manual, qualifying R&D expenditure covers a wide base of eligible expenditure, including "*acquired property directly targeted at R&D activities, R&D personnel costs, a fixed share of operating costs, expenditure for conducting similar operations entrusted to public research organizations or universities, private research organizations approved by the Ministry of Higher Education and Research, or approved scientific or technical experts under the same conditions; costs of maintaining and registering patents; and depreciation and amortization of patents acquired to conduct R&D activities*".

The tax incentives' impact in France

While spending on R&D in the private sector fell in most European countries during 2009, it increased in France (Freitas, et. al 2017). This indicates that there may be a positive impact of the French schemes. The CIR scheme reduces the cost of a researcher by up to one third, effectively making the French researcher among the most cost efficient in the world. Both the CIR and the JEI tax incentives have been evaluated.

JEI was evaluated by Hallépée and Garcia (2012). Using a matching technique, they analysed firms with very similar characteristics that had and had not participated in the scheme. They found that implementing the scheme led to an 8.4 percentage point increase in employment for participating firms between 2002 and 2005, as well as an increase in survival rate and higher wages. When considering the period between 2004 and 2009, they found that participating firms appeared to have had increased growth in sales and in value added. However, they also found that less than half of participating firms made a profit. Nevertheless, they concluded that the increased R&D investment by participating firms were higher than the forgone tax revenue.

Lelarge (2009) analysed the scheme's impact on wages and concluded that the JEI scheme had a six times higher effect on wages than conventional R&D tax credits. Furthermore, it was argued that payroll tax rebates are likely used to retain high-skilled researchers.

Duguet (2010) used a matching technique to evaluate the CIR scheme at the time when it was fully incremental. Input additionality was estimated at 2.33 (relative to the forgone tax revenue) over the years 1993 to 2003 when the control group was firms not using the scheme. When restricting the control group to firms with R&D activities, but not utilising the scheme, the additionality disappeared. Hence, there was no clear evidence of additionality of the incremental R&D tax credit scheme.

Lhuillery et al. (2013) also used a matching technique to estimate the input additionality of the CIR scheme between 1998 and 2009. They estimated that the input additionality is between 1 and 2.6.[43]

Mulkay and Mairesse (2013) studied the R&D tax credit scheme in the period between 2000 and 2007, which is the period leading up to the 2008 reform. They applied three different techniques (fixed effects, first differences and generalized method of moments) and found a long-run elasticity of R&D capital with respect to the user cost of R&D capital of -0.2.[44] Meaning that a decrease in the user cost

[42] The OECD's Frascati Manual is an internationally recognised method for collecting and using R&D statistics. Click her for more information.

[43] During this period the scheme became volume-based.

[44] The elasticity measures the firm's response to changes in a price index of R&D inputs. The user cost of capital can be defined as the actual cost

of ten per cent will induce a level of R&D capital that is two per cent higher. In addition, they simulated the expected effects from the 2008 reform and concluded that in the long run the reform would stimulate R&D expenditure by 12 per cent.[45] This corresponds to a long-run input additionality of 0.7. In 2004, Mulkay and Mairesse estimated the scheme's input additionality to between 2 and 3.5.

Freitas et. al. (2017) found positive input and output additionality effects of the CIR scheme in the whole sample of French firms. Furthermore, they concluded that French firms in more centralised areas on average have a higher propensity to receive tax credits and stronger input additionality effects. Output additionality effects were found not to be significantly different across industries. Taken together, these results imply that highly centralised areas are also those where one may expect a higher average increase in innovation output.

The Netherlands is moving towards more R&D incentives

The Netherlands is amongst the countries with the largest support for private sector R&D, in volume.

The Netherlands actively promotes engaging in R&D activities through a favourable corporate income tax regime and specific R&D tax incentives available to firms operating in the Netherlands. The Netherlands was also amongst the very first countries to implement the so-called patent box.[46] Tax incentives account for 89 per cent of total public support for R&D in the private sector (Appelt, Bejgar, Criscuolo, & Galindo-Rueda, 2016). This is equivalent to 0.16 per cent of GDP.

The tax incentive in the Netherlands, *Wet Becording Speur & Ontwikkelingswerk* (WBSO), is volume-based and was implemented in 1994. WBSO provides tax relief through a payroll withholding tax credit (Straathof, et al., 2014), implying that the scheme reduces wage costs of R&D personnel, rather than corporate income tax. The tax relief is limited to the payroll tax liability of the corresponding tax period. The headline credit rate is 32 per cent for R&D costs up to € 350,000 and 16 per cent for costs above. Unused claims can be carried forward to subsequent tax periods.

For non-personnel costs, a complimentary scheme called R&D allowance (RDA) is available. In case a firm does not have taxable income, it can carry back the expenditure one year or carry forward up to nine years. For self-employed, the carry back is available for three years (forward for nine years). Only projects that have been approved for WBSO, qualify for RDA.

The tax incentives' impact in the Netherlands

The WBSO has been evaluated on different occasions and the studies have found relatively large and significant benefits and an input additionality above 1 (Straathof, et al., 2014). Poet et al. (2003), for example, estimated an input additionality of 1.02 between 1997 and 1998.

Lokshin and Mohnen (2013) utilised firm-level data to analyse the impact of WBSO on the wages of R&D personnel. Their main empirical finding was that there is a significant effect of the R&D tax incentive on the wages of R&D personnel. They estimated a short-term input additionality of 3.24 for small firms and 1.05 for large firms. The long-term

of R&D faced by firms, where an R&D tax incentive is one of the determinants.

[45] French R&D tax credit (CIR) was fully incremental until 2004, when the volume-based part was introduced alongside. It was then reformed to be fully volume-based in 2008.

[46] Patent Box is a form of R&D tax incentive where the corporate tax rate on profits generated from patents are reduced.

input additionality was found to be 1.21 for small firms, but only 0.42 for large firms.

The evaluation by Cornet and Vroomen (2005) used a quasi-experimental design to evaluate WBSO. They found that the scheme yields large positive benefits for start-ups. The extension of the first tax bracket in 2001 was found to have a smaller, but still positive, effect. On average a euro spent in terms of foregone tax revenue induced between € 0,5 and € 0,8 of additional labour expenditure. The extension of the tax bracket, however, showed that every euro in forgone tax revenue resulted in only € 0,1 to € 0,2 spent on labour costs. Straathof et al. (2014) argues that the study by Cornet and Vroomen is a good (and rare) example of a study that uses difference-in-difference with properly defined control group.

Although the input additionality is generally above one, the estimated costs of this scheme seem to outweigh these benefits. Lokshin and Mohnen (2013) compared the additionality with the forgone tax revenue and concluded that welfare losses amounted to 85 per cent of the forgone tax revenue. This is mainly because volume-based schemes are more likely to support activities which would have been carried out anyway.

Austria provides tax relief through a volume-based R&D tax credit scheme

Austria offers a diversified funding landscape for firms engaged in R&D, including both tax incentives and subsidies. About 50 per cent of the public support of R&D in the private sector, stems from an R&D tax incentive. Combining public and private spending on R&D, Austria's spending is above the European target and amounted to 3,1 per cent of GDP in 2016.

Although Austria spends a larger share of GDP on R&D than Norway, it is comparable to Norway both in size, tax rates and in tax incentives for R&D.[47] Austria's R&D tax credit scheme, called *Research premium (Forschungsprämie),* is volume based. The scheme was introduced in 2002, and has since 2011 been the only tax incentive in Austria to promote R&D.[48]

The R&D tax credit can be claimed by any firm that carries out research activities in Austria, regardless of firm size, industry or legal form. Just as with SkatteFUNN, firms can receive a refund of unused credits in the case of insufficient profit. There is no carry-over opportunity.

Furthermore, the *Research premium* differs from SkatteFUNN in that it only has a ceiling for subcontracted R&D.[49] There is no ceiling for R&D costs eligible for tax credit. The main difference between the *Research premium* and SkatteFUNN is that where SkatteFUNN targets SMEs through a higher tax deduction rate, the *Research premium* has a flat rate of 12 per cent.[50]

Over the years, the rate has continuously been increased – most recently in 2016 to 12 per cent. In 2015, R&D expenditure of almost € 502 million was claimed under the scheme.

The tax incentives' impact in Austria

Falk et al. (2009) used a probit model to estimate the scheme's output additionality between 2005 and 2007. They concluded that the use of R&D tax incentives does increase the probability of introducing new products.

[47] The corporate tax rate is at 25 per cent i Austria.
[48] Earlier Austria also had a R&D allowance scheme which was repealed in 2011.
[49] The ceiling is € 1 million.
[50] Because of 2015/2016 tax reform, the R&D tax credit was increased from 10 to 12 per cent. A further increase to 14 per cent will be implemented from 2018.

There is a recently published evaluation of the *Research premium* (Ecker, et al., 2017). The evaluation shows that the scheme is particularly supportive for continuous R&D in firms. The scheme was found to have a larger impact on R&D on the intensive margin, than on the extensive margin. The effects were found to be particularly evident in enabling more investment in R&D infrastructure, acceptance of higher risk and accelerating implementation of projects. The evaluation further found some examples where R&D activities were relocated to Austria thanks to the scheme. The schemes ability to attract private R&D from other countries, where especially the case for countries that did not have R&D tax incentives (e.g. Germany).

Overall, the evaluation found that the scheme gives firms greater flexibility, but it does not stimulate expansion of R&D in firms with low or no R&D activities. For such firms, direct subsidies seem to be more effective. The firms studied in the evaluation reported that between 2010 and 2015 around 14,300 additional highly qualified employees were employed. The beneficiaries' satisfaction in terms of the scheme's design was found to be relatively high.

Because the scheme has become very generous, Ecker et al. (2017) also looks at the potential for misuse. In Austria every project is controlled by tax auditors in detail. Ecker et al. (2017) finds that these audits are often troublesome, especially when the scheme is applied for more advanced R&D (e.g. for prototyping). They further argue that the Frascati Manual is not always the best reference to give a clear guideline for distinctive features of R&D the scheme can be applied for.

Ecker et al. (2017) conclude that the potential for misuse is low as the tax audits are conducted very strictly. The one issue they highlight is the control of the deduction of direct funding for R&D when calculating the amount to be claimed. As with SkatteFUNN, aid received from other R&D enhancing measures should be informed about the application to ensure that the total amount of aid is below the limit set by state aid law. Here, more transparency is asked for.

The UK incentivise R&D through tax allowance

Investment in R&D as a proportion of GDP in the United Kingdom is below that of most other advanced countries. As a measure to improve UK's international position and productivity, a volume-based R&D tax allowance scheme for SMEs was introduced in 2000.[51] The scheme was extended to large firms in 2002 (Straathof, et al., 2014). In 2013 a refundable tax credit for large firms was introduced (Guceri & Liu, 2017).

In 2016, tax incentives accounted for 57 per cent of total public support for R&D in the private sector (Appelt, Bejgar, Criscuolo, & Galindo-Rueda, 2016). This is equivalent to 0.13 per cent of GDP. Total support for R&D in the private sector amounts to 0.23 per cent of GDP. The current R&D tax scheme is permanent, relatively simple, and involves low administrative costs.

The R&D incentive is separated into one scheme for SMEs (*Corporate Tax Credit for R&D*) and one for large firms (*R&D Expenditure Credit Scheme*), offering more generous rates for the former group (Appelt, Bejgar, Criscuolo, & Galindo-Rueda, 2016). As with SkatteFUNN, both schemes are volume-based, and loss-making firms can receive a refund, regardless of size. In addition, the schemes offer an infinite carry-over opportunity.

[51] Prior to the introduction of R&D tax relief, only capital investment for "scientific research" was treated favorably by the tax system. The Scientific Research Allowance (SRA) allowed a hundred per cent depreciation in the year of investment.

Through the *Corporate Tax Credit for R&D*, SMEs can claim a 130 per cent allowance rate, implying that for every £1 spent on R&D, the firm can deduct £1.3 from pre-tax corporate income. The maximum amount a R&D project can receive is € 7.5 million.

For large firms, the *R&D Expenditure Credit Scheme* (RDEC) was introduced in 2013. The scheme offers an 11 per cent credit on the amount of a firm's R&D expenses, set against corporation tax liabilities, meaning that it is less generous than the SME scheme (HM Revenue & Customs, 2017).

The tax incentives' impact in the UK

Although the UK's spending on R&D as a share of GDP is relatively low and stable, the popularity of the R&D tax incentives has been increasing, especially during the financial crisis when the schemes became more generous.

Bond and Guceri (2012) measured the effect of the introduction of R&D tax credits on beneficiaries' cost of capital for R&D investment for large firms, and specifically on the R&D intensity in manufacturing. They found that although the share of business expenditure on R&D (BERD) has been relatively stable, there has been a significant increase in R&D expenditure in the manufacturing sector. Using a difference-in-difference framework, Guceri (2013) found an increase in R&D expenditure of 18 per cent in the group who used the tax incentive, relative to those who did not.

An evaluation carried by HM Revenue and Customs (HMRC) (2010) for the period between 2000 and 2007 and another study that analysed R&D effects in Northern Ireland between 1998 and 2003 by Harris et al. (2009) concluded that the R&D tax reliefs have had a positive impact on R&D expenditure. However, Harris et al. (2009) found that the productivity of firms in Northern Ireland could only be increased with very generous benefits. As noted by Harris et al. (2009), these effects can be lower in practice due to a relatively inelastic labour supply curve in the region.

A survey conducted by HMRC among firms undertaking R&D activities showed that firms believed R&D tax incentives enhanced their spending on R&D. However, in large firms R&D activities appeared not to be sensitive to R&D tax incentives, as their R&D investment are determined by long-term strategic plans. Nevertheless, in the presence of a tax allowance, firms were more inclined to invest in more risky projects.

Dechezleprêtre, Einiö, Martin, Nguyen and Van Reenen (2016) utilised firm-level data for SMEs and the regression discontinuity design to assess the impact of tax incentives on R&D and innovation. They concluded that the R&D tax incentives do have a significant positive effect on R&D expenditure and on patenting. The elasticity of R&D with respect to changes in costs was estimated to around 2.6. The increase in R&D was estimated to 1.7 times the forgone in tax revenue. The largest impact was found in smaller firms and should not be generalised across the entire population.

Guceri and Liu (2017) also found evidence that for every pound forgone in corporation tax income the additional R&D expenditure was larger than one, but slightly lower than in Dechezleprêtre et. al. (2016), namly 1.3 pounds in additional R&D per forgone pound. Dechezleprêtre et. al. (2016) also estimated that the aggregate business expenditure on R&D had increased by 10 per cent between 2006 and 2011 due to the tax incentive. This implies that the relatively stable ratio of BERD to GDP, possibly would have been much lower in the absence of the scheme.

4 Input additionality of SkatteFUNN

To assess how much additional R&D that comes from firms receiving tax credit on their R&D expenditures, i.e. the scheme's input additionality, we apply two different econometric approaches. Adapting the "discontinuity approach" applied in the previous evaluation of the scheme, we find that firms with R&D expenditures below the limit of tax deductible project costs are stimulated to increase their R&D investment, implying that reducing firms' costs on their marginal investment increases R&D. Applying a general difference-in-differences approach to study how changes in the scheme have affected firms' investment in R&D, we find that the scheme's overall input additionality is high, but the effects vary significantly depending on the type of change and at what point in time firms enter the scheme (i.e. which generation of beneficiaries they belong to). For all generations the input additionality is highest in the beginning and decreases thereafter. The only exception is the policy changes in 2014 and 2015, where the additionality is higher.

SkatteFUNN is intended to stimulate R&D among Norwegian firms by reducing the cost of R&D through tax credits. An increase in total R&D investment can be achieved by initiating new R&D projects (otherwise not initiated) in firms that already engaged in R&D (intensive margin) or by stimulating firms that have not previously been engaging in R&D to invest in R&D (extensive margin). We evaluate SkatteFUNN's effect on R&D investment at both margins.

There is a vast amount of evaluations finding positive impacts of R&D tax credit schemes. The previous evaluation of SkatteFUNN, conducted by Statistics Norway, concluded that overall the scheme worked as intended (Cappelen, et al., 2008). The evaluation found that firms receiving support through SkatteFUNN have higher growth in R&D investment than other, comparable, firms. More specifically, the evaluation estimated that for every forgone krone in tax revenues, Norwegian firms invest about two extra kroner in R&D. Thus, the so called "bang-for-the-buck" (BFTB) equals 2.[52]

A later evaluation of several R&D and innovation supporting schemes, including SkatteFUNN (Cappelen, et al., 2016), concluded that SkatteFUNN was the most effective R&D scheme with respect to value added. It did, however, not focus on input additionality. Recently Freitas, et al. (2017), who study additionality effects of SkatteFUNN compared to tax credit schemes in France and Italy, have also found positive input additionality of SkatteFUNN. However, reporting variation of effects across different manufacturing industries, they do not report any efficiency measure.

The BFTB found in the previous evaluation of SkatteFUNN seems to be high compared with other results in the (international) literature. The magnitude of the BFTB estimate depends on how it is calculated and on the type of R&D tax incentive, which makes it difficult to compare across evaluations.[53] However, the most common result in recent studies is a BFTB around one (CPB, 2014; Straathof, et al., 2014; Becker, 2015).[54]

To answer whether, and to what degree, SkatteFUNN has contributed to increase firms' R&D investment we must perform a counterfactual analy-

[52] This terminology is commonly used in the European policy debate to express the effect of R&D incentive policies in terms of additional R&D as a fraction of the governments' forgone tax revenue. A BFTB of 1 would imply that for every krone of forgone tax revenue, an additional krone of R&D is undertaken by the firm. BFTB lower (higher) than 1 indicates that less (more) extra R&D is generated by the scheme than the forgone tax revenue.

[53] SkatteFUNN is a volume-based scheme. For such schemes BFTB is typically below 1 (Mohnen & Lokshin, 2009).

[54] The summary table in Straathof et al. (2014, p. 33) documents 10 estimated values of BFTB for a range of countries and time periods. Of these 10 values, four are equal to 1 or larger, and the remaining six are positive but smaller than 1. Similar results are further confirmed by Becker (2015).

sis. That is, we need to compare actual R&D investment with the investment that would have been realised in the absence of the scheme.

A counterfactual analysis of SkatteFUNN is not a trivial exercise. Given that assignment to SkatteFUNN is not random, but a voluntary decision,[55] a direct comparison of beneficiaries and non-beneficiaries will give a biased result. Firms deciding to use the scheme will likely make their decision based on factors not shared with firms not using the scheme. Some of these factors we can observe and account for, others not. Thus, an observed increase in R&D among beneficiaries of SkatteFUNN may result from such firm specific factors, rather than of the scheme itself.

A range of quasi-experimental methods are developed to account for endogeneity and self-selection as mentioned above. Among them are regression discontinuity approaches and matching procedures.

Using a discontinuity approach, Hægeland and Møen (2007) evaluated the input additionality in SkatteFUNN for a three-year period after the introduction of the scheme in 2002. Their findings suggest that the scheme had stimulated firms to increase their R&D expenditures. Furthermore, they find that the estimated effect is largely driven by firms that in some years prior to SkatteFUNN has reported zero R&D, which confirms that the schemes' additionality is highest among firms with no prior R&D experience and in line with the firms' self-assessed additionality (see chapter 4.1).

Our first approach to assess the scheme's input additionality follows Hægeland and Møen (2007), i.e. we use the same discontinuity approach to evaluate the effect of the *increase in the limit* of tax-deductible R&D expenditures in 2009.[56] As we evaluate a change in the scheme rather than its implementation, our sample of firms differs from that in the previous evaluation. Firms not engaging in R&D after the implementation of the scheme are, strictly speaking, not affected by an increase in the limit of tax-deductible R&D investment (they have not taken advantage of the opportunities already there). Any changes in these firms' R&D expenditures is likely due to other factors than the change in 2009. Thus, unlike Hægeland and Møen (2007), we exclude firms not engaging in R&D prior to the change from our sample.

Our results are in line with the previous evaluation, though of a smaller magnitude, confirming that only firms receiving subsidies on their marginal investment are stimulated to do more R&D than they otherwise would have done. Furthermore, we find that firms are stimulated to continue doing R&D. We do not find the change in 2009 to encourage more firms to invest in R&D, which supports our hypothesis that if they did not exploit the possibilities that existed in the years following the implementation of the scheme, an increase in the limit would not affect their behaviour.

Our second approach is a generalised difference-in-differences approach, following Mohnen et al. (2017) who have evaluated an innovation box tax policy instrument in the Netherlands. The main advantage of this approach is that it allows us to consider any change in the scheme, implying that we can exploit the whole period available for evaluation.

Our main contribution, compared to Mohnen et al. (2017), is that we combine the generalised diff-in-

[55] All firms that are subject to taxation in Norway are eligible to apply.
[56] The limit of tax-deductible R&D expenditures was also increased in 2014 and 2015. However, to compare firm behaviour after a change in the scheme with behaviour prior to the change we need data for the period after the change. Thus, we are not able to conduct such an analysis for the recent changes and limit our analysis to the period 2003-2013.

diff approach with a matching procedure. This procedure allows us to cope with the self-selection problem by selecting controls among firms not using SkatteFUNN, but that are as similar as possible to firms using SkatteFUNN (given their observable characteristics) with respect to probability of participation in the scheme *prior to its introduction*.

Though the matching procedure results in omitting a considerable part of SkatteFUNN beneficiaries from the estimations, it ensures the most reliable and unbiased results, representative for the main beneficiaries of SkatteFUNN.[57] Another contribution is that in addition to an overall estimate of the BFTB, we can estimate this measure for different generations of beneficiaries (defined by the first year a firm use SkatteFUNN) and each policy regime. We also check how this measure differs between SMEs and large firms and between firms with continuous and sporadic R&D behaviour.

The generalised diff-in-diff approach confirms a positive and strongly significant input additionality of SkatteFUNN. The overall BFTB measure in the main model is equal to 2.07.[58] However, it varies significantly across user-generations and regimes. The input additionality is highest among the first two generations of SkatteFUNN beneficiaries (firms who entered the scheme in 2002-2003 and 2004-2006) and equal to 2.55 and 2.42 respectively. The lowest additionality is estimated for the generation of firms that started to use SkatteFUNN in the period 2007-2008 (when the limit for hourly costs was implemented) and is equal to 1.06. This user-generation is also the only generation that did not show any additional R&D expenditures during the period 2009-2013.

For all generations the input additionality is highest in the beginning and is declining thereafter, until the limit for tax-deductible R&D investments was increased significantly in 2014 and 2015. That is, the development in input additionality of SkatteFUNN over time gets a wide "U-shape". However, there is reason to believe that this positive response at the end of our evaluation period is not permanent but would diminish after some years if not any additional changes of the scheme had happened.

Our estimate of BFTB for SMEs is higher than for large firms only in the period just after the introduction of SkatteFUNN. Both SMEs and large firms demonstrate similar efficiency measures in the later periods. As expected, firms with R&D activity prior to the start of the SkatteFUNN project exhibit lower input additionality than firms with no R&D activity prior to their use of SkatteFUNN.

4.1 Self-reported input additionality

One possible way to identify the scheme's additionality is to ask the beneficiaries whether the tax credit has induced higher R&D investments than what otherwise would have been. The challenge with this approach is the firms' lack of incentive to answer accurately and truthfully (firms that want the scheme to be maintained have incentives to respond positively regardless of actual effect). Despite these challenges, it is of interest to get a picture of the firms' own assessment of the scheme. Thus, before we present the econometric analyses, we will provide a summary of firms' self-reported input additionality in our survey to beneficiaries of SkatteFUNN.

[57] Between 44 and 58 per cent of firms using SkatteFUNN are not matched and hence omitted, depending on the matching variables. Among them are the largest firms and firms that frequently use other types of support. However, most SkatteFUNN beneficiaries are SMEs and about 70 per cent are beneficiaries of SkatteFUNN only. Thus, we consider our results to be representative for this "main group" of beneficiaries of the scheme.

[58] This result is robust with respect to matching procedure and choice of explanatory variables.

While the econometric analyses focus on the effects of SkatteFUNN on firms' overall R&D investments, firms in the survey reveal whether a specific project would have been conducted or not in absence of the scheme. In addition, the self-reported additionality serves as an indication of what we should expect to find in the counterfactual analyses below.

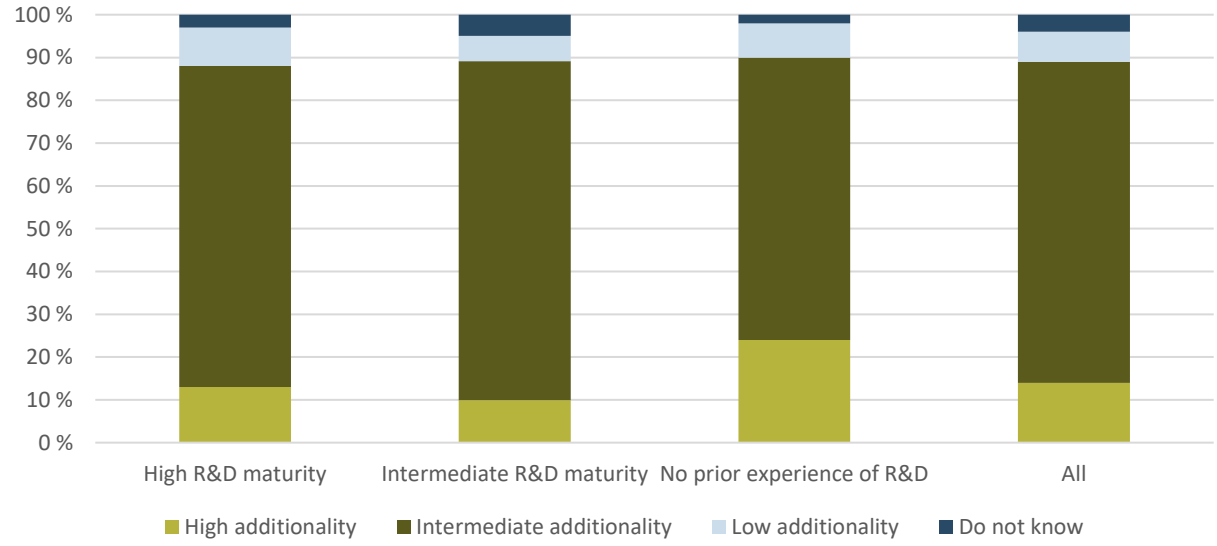
Our survey indicates that most projects would have been conducted independent of the tax credit, but with a delay or in a smaller scale. That is, the scheme does not seem to have very high input additionality. This result is in line with the ones reported in the previous evaluation of the scheme (Foyn & Kjesbu, 2006).

Firms were asked what would have happened to the project if it was not supported through SkatteFUNN. Projects that would have been conducted in the same way without SkatteFUNN support are considered to have low additionality. Projects that would have been reduced in some way (scaled down, conducted without external R&D partner or postponed) are considered to have intermediate additionality. Projects that would not have been conducted without SkatteFUNN support are considered to have high additionality.

Our survey imply that the scheme's additionality varies with the firms' R&D maturity (cf. figure 4.1). Among firms with no prior R&D experience 24 per cent state that the project would not have been conducted without SkatteFUNN support, compared to 14 per cent among all firms.

Firms with 50 or more employees claim the highest additionality (19 per cent report high additionality versus 13 per cent among micro-firms, i.e. with 0-4 employees). Among projects that were initiated by a partner (another firm or an R&D institution) or as a result of a previous project, additionality was also high (20 per cent and 30 per cent report high additionality, respectively). As we shall see later in this chapter, SkatteFUNN is an appreciated scheme. This, together with firms' incentives to answer strategically (see above), suggest that these results probably overestimate the level of additionality to some extent.

Figure 4.1 Self-assessed additionality of latest SkatteFUNN project. Share of firms. N=590.



Source: Technopolis' user survey

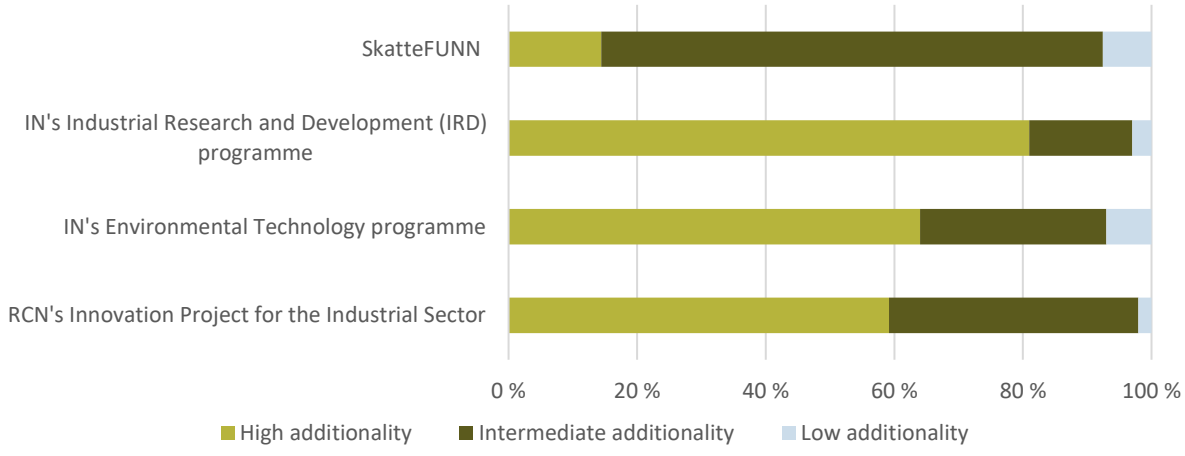
Although questions of similar nature have been asked in previous studies of SkatteFUNN, any direct comparison should be made with caution, as the specific formulation of a survey question can influence results. With this caveat in mind, we note that the result in this survey echoes the findings of both the previous evaluation of SkatteFUNN and the annual user survey by the Research Council of Norway (RCN) (Foyn & Kjesbu, 2006; The Research Council of Norway, 2017).

With the same type of caveat in mind, we can compare additionality across different schemes with similar objectives as SkatteFUNN (cf. figure 4.2). From this comparison we can conclude that SkatteFUNN projects are different in terms of additionality. The share of projects with high additionality is substantially lower for SkatteFUNN, relative to comparable schemes by Innovation Norway and RCN.

There can be several explanations for this difference. Compared to the other schemes, the amount of support is considerably lower for SkatteFUNN. It is probably also linked to the fact that the SkatteFUNN projects are more likely to be strategically important and would be conducted regardless of tax deduction. Another possible explanation is that SkatteFUNN is a rights-based scheme (support is granted if basic eligibility criteria are fulfilled), whereas the other measures are competitive. This is further indicated by a recent study finding that "Firms seem to take SkatteFUNN support for granted, and it is not perceived as R&D support in the same sense as a [regular RCN] grant" (Åström, Opdahl, Håkansson, & Bergman, 2017).

Most of the additionality from SkatteFUNN is reported as intermediate. Many interviewees describe that SkatteFUNN support is not vital for the conduction of a project, but it determines the ambition level and allows the firm to take higher risks and hence increase the benefits of the project. Such reasons are less relevant in the case of other supporting schemes. The sum of high and intermediate additionality is quite similar and above 90 per cent for all the schemes.

Figure 4.2 Self-assessed additionality of selected R&D schemes



Sources: Bergem, B.G. and Bremnes, H., 2014, "Resultatmåling av brukerstyrt forskning" (first bar from the bottom); Innovation Norway's Customer effect study 2016 (second, third and fourth bar); Technopolis' user survey (first bar from the top)

4.2 Data on R&D expenditures

The main challenge when evaluating public R&D funding is limited data on firm's R&D investments. While detailed firm-level data (accounting data, data on employees etc.) is available for almost all Norwegian firms,[59] information on R&D investments is primary available from annual R&D surveys that cover only a small part of the population of firms.[60] The number of firms in a survey varies between 4,000 and 6,000.

There are 34,466 firm-year observations in the SkatteFUNN database in the period 2002-2015. Of these, more than half are firms with less than 10 employees. Thus, most beneficiaries of an R&D tax credit are not included in the annual R&D surveys. Only 10,292 (30 per cent) are present in the R&D surveys in the period 2002-2015 (cf. Table 4.1).

Table 4.1 Firm-year observations by data source and number of employees. 2002-2015.

Obs. in SkatteFUNN database		Yes	
Obs. in R&D survey	Yes	No	Yes
No or missing employees	66	2,534	1
1-4	497	10,113	47
5-9	5,993	5,319	546
10-19	15,671	3,427	2,147
20-49	19,332	2,305	3,085
50-149	17,692	368	2,895
150+	9,058	108	1,581
Total	68,309	24,174	10,292

Source: Statistics Norway and Samfunnsøkonomisk analyse AS

To increase the number of observations with information on R&D investments, we have combined all available information on firms' R&D investments from all relevant data sources. These sources and how they are used to impute relevant variables is explained below. Description of all data sources used in the evaluation is available in Appendix B.

RCN collects information on firms' R&D expenditures three years prior to applying for R&D tax credit as part of the SkatteFUNN application, in addition to the budgeted R&D costs for each project. If we make use of these data, we obtain additional information on R&D expenditures for almost all observations included in the SkatteFUNN database but not in the R&D surveys.

Comparing the additional R&D data with data in the R&D surveys (for firms present in both datasets) it seems the accuracy increases with firm size. We are not able to check the accuracy of these data for the smallest firms, since they are not included in the survey. However, in parts of the evaluation we prefer to use this historical information to keep most SkatteFUNN firms in the analysis. Moreover, this information is mainly used to control for the previous R&D experience and the accuracy of the amount is not crucial.

We also have information on other types of R&D support from our own database on public support for all Norwegian firms. The database includes information on grants received from RCN, EU-programs and regional research funds, as well as all the relevant schemes administered by Innovation Norway. Based on these data we calculate R&D expenditures by multiplying annual grants by two (assuming R&D grants cover about 50 per cent of the project costs).

[59] For the analysis we use data on all Norwegian limited liability firms included in the Accounts statistics from 1999 to 2015. The number of firms in this dataset increases from about 130,000 in 1999 to about 210,000 in 2015. By supplementing these data with information from the Tax Register, the Register of Employers and Employees and the National Education Database and excluding observations with missing information on some key variables we obtain a panel of firms with number of observations varying from about 128,000 in 1999 to 207,000 in 2015 and 2,880,620 firm-year observations in total.

[60] The sample of firms in the surveys are selected using a stratified method for firms with 10-50 employees, whereas all firms with more than 50 employees are included. A survey among firms with less than 10 employees is conducted every other year after 2006.

Finally, we use information from the annual R&D surveys to collect budgeted R&D expenditures for the next year.

We construct an extended measure of R&D expenditures, giving highest priority to the information on ongoing R&D from the R&D surveys, then to information from the SkatteFUNN applications, our database on public support of the private sector (Samspillsdatabasen) and finally, to the budgeted R&D expenditures from the R&D surveys. Combined, this measure comprises total R&D expenditures for each firm. By extrapolating the data, we have almost doubled the number of observations on R&D expenditures and most importantly gained information on R&D expenditures for small firms with less than 10 employees (cf. Table 4.2).

Table 4.2 Number of observations by source of information and number of employees. 2002-2015.

	R&D survey		Extended data	
	R&D=0	R&D>0	R&D=0	R&D>0
No or missing	58	8	3,463	4,690
1-4	398	99	5,630	16,575
5-9	4,881	1,112	7,454	10,161
10-19	11,856	3,815	13,774	10,573
20-49	14,016	5,316	15,261	11,064
50-149	11,370	6,322	10,913	8,767
150+	4,959	4,099	4,507	5,390
Total	47,538	20,771	61,002	67,220

Source: Statistics Norway and Samfunnsøkonomisk analyse AS

4.3 Estimation of input additionality using a discontinuity approach

In this section we follow Hægeland and Møen (2007) and evaluate the input additionality of SkatteFUNN using a "discontinuity approach". We evaluate the effect of an increase in the limit of tax-deductible R&D investments, by comparing outcomes for firms with R&D expenditures above and below the given cap. Evaluating effects of a change in the scheme, rather than its implementation, we are (in this part of the evaluation) mainly interested in studying behavioural changes for firms that already engage in R&D (effects on the intensive margin).

Unlike Hægeland and Møen (2007), we exclude firms not engaging in R&D prior to the change from our sample. An increase in the limit of tax-deductible investment, reduces the cost on marginal investments facing firms. Thus, the increased limit is expected to mainly affect firms that were already engaging in R&D at a certain level. Firms not motivated to engage in R&D after the introduction of SkatteFUNN will probably not consider the increase in the limit as crucial to their decision to invest in R&D. Therefore, we do not expect to find significant effects in number of firms engaging in R&D (the extensive margin).

The change in 2009 was mainly motivated by the economic downturn due to the financial crisis of the late 2000s (see chapter 0). Studying the effectiveness of R&D policies in Europe during the crisis, Aristei, et al. (2016) find no additionality effects of R&D subsidies in the years between 2007 and 2009. However, they find that public subsidies to R&D prevented reductions of firm R&D efforts in the aftermath of the economic crisis. Based on these findings, we expect to find small, if any, additionality effects of the change in SkatteFUNN in 2009.

4.3.1 Exploiting the discontinuity in the scheme

At the time the scheme was implemented, the R&D tax credit was limited to investments up to NOK 4 million in intramural R&D or NOK 8 million in total R&D (cf. chapter 2.2.3). All firms, independent of the amount of R&D investments, received a subsidy with the implementation of SkatteFUNN. For firms with R&D expenditures above the cap before the scheme was implemented, however, increasing their R&D expenditures would not increase their subsidy, as their investments already exceeded the

maximum possible amount. Thus, they did not receive any subsidies on their marginal investments. Firms that invested less than the cap in absence of the scheme would, on the other hand, have an incentive to increase their R&D expenditures as it would increase their subsidy (Hægeland & Møen, 2007).

In 2009, the limit for R&D tax credit was increased to NOK 5.5 million in intramural R&D and NOK 11 million in total R&D. Thus, firms with positive R&D expenditures close to the old limit (NOK 4 million) got further incentives to increase their R&D expenditures, as they could do this and still receive subsidies on their marginal investments.

The basic idea behind the regression discontinuity design is that assignment to the treatment is determined by the value of a predictor being on either side of a fixed limit. Though this predictor may itself be associated with the potential outcomes, any discontinuity of the conditional expectation of the outcome as a function of this predictor at the cut-off value, is interpreted as evidence of a causal effect of treatment (Imbens & Lemieux, 2008).

Exploiting the discontinuity in SkatteFUNN means that we compare firms with R&D expenditures below and above the limit for tax deductible expenditures and assume that the difference in R&D growth between the two groups is due to the fact that firms in one of the groups received a tax credit for their marginal R&D investments (Hægeland & Møen, 2007).

4.3.2 Sample construction and estimation strategy

In this part of the evaluation we want to assess the effect of the increase in the cap in 2009. Given that SkatteFUNN has been available to all since 2003, and that there has been made changes in the cap every year since 2014, we have restricted the data to the period 2003-2013. We also restrict our sample to firms that report strictly positive R&D expenditures and are never observed with investments above NOK 40 million in a single year.[61] Thus, all firms in the sample are R&D performers, and the largest R&D performers are excluded. Furthermore, we split the sample in two groups and compare firms with average R&D expenditures above and below NOK 5.5 million prior to the change in the cap.

To secure comparability of the two groups it is desirable to compare observations close to either side of the limit. However, narrowing the sample down to firms right above and right below the cap implies a trade-off; it causes a loss of observations and it increases the possibility of misclassifying firms (Hægeland & Møen, 2007).

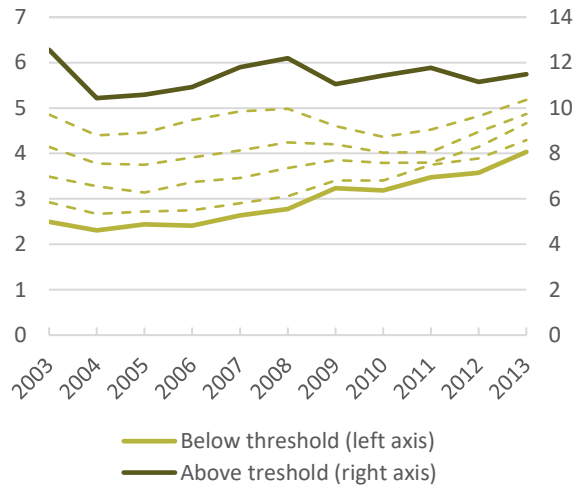
By experimenting with sample restrictions around the initial limit of NOK 4 million, Hægeland and Møen (2007) show that the high additionality is largely driven by firms doing no or little R&D prior to the implementation of SkatteFUNN. For firms with no R&D or R&D investments well below the initial cap of NOK 4 million prior to 2009, it seems reasonable to assume that increasing the limit would not be decisive for their choice to invest more in R&D or not. Thus, we have estimated the effect of the increased limit for different restrictions on the sample of firms below NOK 5.5 million in average R&D investments prior to the change.

A first glance at the development in R&D expenditures for firms above and below the cap, indicate that an increase in the limit for tax deductible intramural R&D encouraged firms that used to invest less than NOK 5.5 million in R&D to increase their

[61] Hægeland and Møen (2007) include firms that are observed with positive investments at least one year prior to the introduction to SkatteFUNN. Given that we evaluate an increase in the amount one could invest in R&D and still receive a subsidy on the marginal investment, we are mainly interested in behavioural changes among firms already investing in R&D.

investments (cf. Figure 4.3). By narrowing the sample of firms with R&D investments below the cap to firms that must have a certain level of R&D investments, it appears that the trend is approaching that of firms above the cap.

Figure 4.3 Mean real intramural R&D for firms with and without a tax subsidy on the margin.[1,2] NOK million.



1) Only R&D performers (firms with positive R&D) that have received an R&D tax credit are included.
2) The dashed lines indicate the development for different restrictions on the sample of firms below the limit (average above NOK 1m, NOK 2m, NOK 3m and NOK 4m respectively).

Firms that used to invest less than NOK 5.5 million in R&D prior to the increase in the cap in 2009 had on average 17 percentage points higher growth in R&D investments from 2008 to 2010, compared to firms that invested more than NOK 5.5 million in R&D in the same period (cf. Table 4.3).

A two sample mean comparison t-test with unequal variance indicate that the difference between the two groups is statistically significant and suggest that the tax credit scheme stimulates to additional R&D. However, if we limit the sample of firms below the cap to firms with average intramural R&D above NOK 1 million, the difference in means is reduced to 14 percentage points (significant at the 10 per cent level) and there is no significant difference in means if we narrow the sample to firms with R&D investments above NOK 2 million prior to 2009.

For firms with R&D investment below the cap for tax deduction it is reason to believe that aggregating reported R&D expenditures per firm from the applications to SkatteFUNN would serve as a good estimate of the firm's R&D expenditures, assuming they apply for tax credit if they are R&D performers. However, firms above the cap have no reason to apply for tax credit after exceeding the cap. It seems that this is the case when looking at applicants' budgeted R&D expenditures. For the period 2003-2013 there is a concentration of aggregated investments per firm around NOK 4 and 5.5 million in intramural R&D (cf. Figure 4.4).

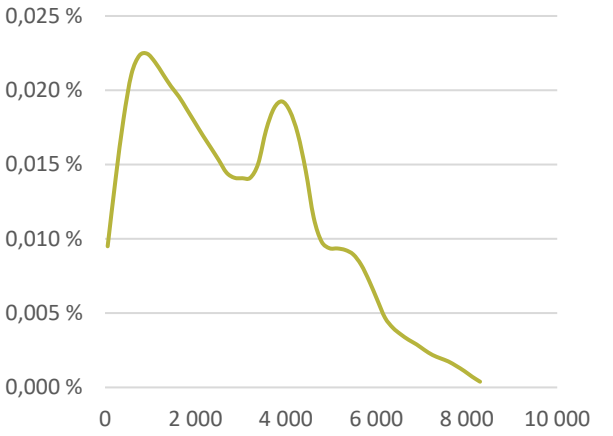
Table 4.3 Growth[1] in real intramural R&D for firms with and without a tax subsidy on the margin[2]

Growth in real intramural R&D from 2008 to 2010	Average pre-2009 intramural R&D expenditures		
	< 5.5 m	> 5.5 m	Difference
10th per centile	-0.67	-0.84	-0.17
Median	0.04	-0.07	0.11
90th per centile	0.81	0.46	0.35
Mean[3]	0.07	-0.10	0.17
Std. Err.	0.04	0.06	
Average pre-2009 intramural R&D	2,506,300	11,416,800	
N	212	86	

1) $(R\&D_{2010} - R\&D_{2008})/(0.5 \times R\&D_{2010} + 0.5 \times R\&D_{2008})$
2) Only R&D performers (firms with positive R&D) that received a tax credit in 2010 are included.
3) The difference between the two means are significant at 5 per cent significance level.

Among firms included in the R&D surveys, 30 per cent of the observations reported positive R&D (total R&D expenditures greater than zero). The share of reported R&D expenditures greater than zero increases with firm size (cf. Table 4.5).

Figure 4.4 Estimated distribution of intramural R&D as reported in the application to SkatteFUNN.[1] NOK 1 000. 2003-2013.



[1] Includes firms that report positive values below NOK 8 million in intramural R&D.
Source: Statistics Norway and Samfunnsøkonomisk analyse AS

Table 4.4 Firm-year observations included in annual R&D surveys by reported R&D.[1] 2003-2008.

	R&D = 0	R&D > 0	Share with positive R&D
No or missing employees	11	5	-
1-4 employees	89	25	-
5-9 employees	2,437	494	16.9 %
10-19 employees	5,886	1,580	21.2 %
20-49 employees	4,639	1,953	29.6 %
50-149 employees	3,968	2,463	38.3 %
150+ employees	1,657	1,523	47.9 %
Total	18,687	8,043	30.1 %

[1] Entire population of firms with more than 50 employees. Stratified sample for firms with 10-50 employees.
Source: Statistics Norway and Samfunnsøkonomisk analyse AS

For the entire period 2003-2013, there are 1,559 firm-year observations that report positive R&D in one or more years in the three-year period prior to applying for SkatteFUNN but report no R&D for the same years in the R&D surveys. Furthermore, there are 449 firm-year observations with a positive R&D tax credit that report no R&D in the R&D surveys or for the three years prior to their application. This suggest that there is some uncertainty associated with the reported zeros in the R&D surveys. This, together with our interest in evaluating whether the increased cap encouraged existing R&D performers to invest more in R&D, speaks for exclusion of firms reporting zero R&D some years.

When interpreting the econometric result below it is important to keep in mind that an essential share of SkatteFUNN beneficiaries fall out of the analysis due to lacking data on R&D expenditures for firms with less than 10 employees. Thus, findings from the analysis based on data in the R&D surveys cannot necessarily be generalised to smaller firms, although many of the same incentives and mechanisms probably also apply for these (Cappelen, et al., 2008).

One possible improvement of the data set is to expand the R&D information with applicants' reported R&D three years prior to applying for an R&D tax credit (see chapter 1.1). This only include firms that apply for R&D tax credit and not the entire population of enterprises. However, we also run our estimations on the extended data to check the robustness of our main results.

Like Hægeland and Møen (2007), we use a fixed effects regression approach to identify the causal effect of SkatteFUNN. Our sample consists of firms that are present in the R&D surveys and that have reported strictly positive R&D every year. Firms reporting real R&D expenditures above NOK 40 million at some point are excluded, as well as observations with R&D intensity above 5, and observations with positive R&D tax credit but zero R&D in the R&D survey.

In the following we report our results from estimating minor modifications of the relationships specified in Hægeland and Møen (2007) on our sample. That is, we follow their method to estimate the effect of the change in the cap in 2009.

4.3.3 Assessing short term additionality

Hægeland and Møen (2007) start out by estimating a simple descriptive relationship where firms' R&D expenditures are explained by their sales, direct R&D subsidies, firm specific fixed effects and year dummies capturing common macroeconomic shocks and firms' specific temporary shocks. A change in the scheme should be picked up by the year dummies as firms should do more R&D than what they otherwise would do when there is a generous subsidy regime (Hægeland & Møen, 2007). This relationship is presented by the following equation:

$$\ln(R\&D_{it}) = \alpha + \gamma \ln(sales_{it}) + \chi \ln(subsidies_{it}) + \sum_{t=1}^{t=T} \delta_t D^{year\ t} + \eta_i + \epsilon_{it} \quad (4.1)$$

Output (proxied by sales) is a function of input (R&D), and sales could thus be affected by the treatment. Furthermore, other R&D subsidies is likely to be complementary to SkatteFUNN (see chapter 7 for an overview of schemes commonly used together with SkatteFUNN).

As both sales and R&D subsidies may be considered as endogenous, we have instrumented these controls with their lagged values. Other solutions are to use pre-treatment values of sales and direct subsidies or drop the controls altogether. Including firm fixed effects, the pre-treatment variables become redundant. We could also have dropped them altogether, but this does not change the results in a significant manner.

The estimated coefficients are reported in column (1) in Table 4.5. The year dummies represent differences in average R&D expenditures compared to 2003 and 2004 (the base years). Except for a few years, the estimated coefficients indicate relatively little variation in average R&D expenditures and there is no clear shift in the level of R&D expenditures after the limit for tax-deductible expenditures was increased. Comparing only pre- and post-change years, as in column (2), suggest that firms do not invest significantly more in R&D after the cap was increased.

Next, we take into account that only firms investing less than NOK 5.5 million have an incentive to increase their R&D expenditures when the cap is increased. Thus, we include interaction terms between the year dummies and a dummy for average pre-change R&D expenditures being below 5.5 million. Thus, $D^{BelowCap}$ is equal to one if a firm on average invested less than NOK 5.5 million in R&D in the period 2003-2008.[62]

$$\ln(R\&D_{it}) = \alpha + \gamma \ln(sales_{it}) + \chi \ln(subsidies_{it}) + \sum_{t=1}^{t=T} \delta_t D^{year\ t} + \sum_{t=1}^{t=T} \phi_t D^{year\ t} \times D^{BelowCap} + \eta_i + \epsilon_{it} \quad (4.2)$$

Conditioning on sales, subsidies and firm specific levels of R&D expenditures, there seems to be a significant difference between firms above and below the cap at the end of our estimation period in the years after the cap increased (cf. column (3) of Table 4.5).[63]

If we only include an interaction between the post-change dummy and the dummy for average R&D being below NOK 5.5 million prior to the change, as in column (4), the coefficient is positive and significant at the 1 per cent level. That is, firms that have their marginal cost of R&D expenditures reduced

[62] See Hægeland and Møen (2007) for a discussion of which measure that best predict R&D expenditures in absence of SkatteFUNN.

[63] We may capture effects of the increase in the maximum hourly wage rate in 2011 or the change in the definition of R&D. However, the changes affected both firms above and below the cap.

(firms below the cap) have larger R&D expenditures after the increase in the cap, compared to firms above the cap.[64]

The point estimate of 0.225 log points implies about 25 per cent increase in R&D expenditures. This is a lower estimate than what Hægeland and Møen (2007) find when they evaluate effects of the introduction of SkatteFUNN; their corresponding estimate imply a little more than a doubling of R&D expenditures in the years after the introduction of the scheme. However, they find that the effect is largely driven by firms that in some years prior to SkatteFUNN have reported zero R&D. Thus, the high growth is typically happening from a very low level.

If we include firms that report zero R&D in some years prior to the increase in the cap the estimated coefficient becomes negative but not significantly different form zero, whereas including firms with positive R&D expenditures in at least one year prior to the change, and treating zero R&D as missing, gives similar results as the ones reported in Table 4.5. If we include all firms in the R&D survey, even those who never report positive R&D, the estimated coefficient becomes insignificantly different from zero.

Given our specification of the core sample (restricted to firms reporting strictly positive R&D), our results are not driven by firms with zero R&D prior to the change.

However, if our results are driven only by firms with very low levels of R&D it is challenging to argue that increasing the limit of tax-deductible expenditures will motivate firms to invest more in R&D.

If we restrict the sample of firms below the cap to firms with average intramural R&D prior to the change above NOK 1 million, we find a slightly smaller effect than the one reported for our core sample (cf. column (1) of Table 4.6). Restricting the sample to firms with average R&D above NOK 2 million in the years prior to the change reduces the estimated increase in R&D expenditures to 14 per cent (estimated 0.133 log points in column (2)).

If firms consider a marginal investment as whether to invest one additional krone in R&D, increasing the cap only change the marginal incentives for firms with R&D investments between NOK 4 million and 5.5 million. However, if they make these marginal decisions on a project level (whether to take on a new project or not), we can argue that the change in the limit for tax-deductible investments also affects firms with pre-change investments at a certain level but below NOK 4 million.

Restricting the sample to firms with investments above NOK 3 and 4 million confirms a positive difference in investment growth between firms below and above the limit. However, these restrictions lead to a significant loss of observations and the effect is no longer statistically significant.

[64] The results in column (4) corresponds to the simple comparison of the two groups in Table 4.3.

Table 4.5 Short term additionality of SkatteFUNN

	(1) Core sample	(2) Core sample	(3) Core sample	(4) Core sample
Log Sales	0.317***	0.491***	0.314***	0.315***
	(0.086)	(0.144)	(0.085)	(0.085)
Log Direct Subsidies	0.124***	0.253**	0.119***	0.124***
	(0.038)	(0.106)	(0.038)	(0.038)
2005	0.332***		0.301***	0.332***
	(0.120)		(0.104)	(0.119)
2006	0.292**		0.306**	0.293**
	(0.127)		(0.119)	(0.126)
2007	0.236*		0.258**	0.239**
	(0.122)		(0.124)	(0.120)
2008	0.253**		0.283**	0.257**
	(0.123)		(0.125)	(0.122)
2009	0.297**		0.244**	0.142
	(0.123)		(0.117)	(0.124)
2010	0.260**		0.122	0.105
	(0.121)		(0.122)	(0.122)
2011	0.268**		0.146	0.112
	(0.126)		(0.128)	(0.127)
2012	0.234*		0.027	0.079
	(0.126)		(0.123)	(0.126)
2013	0.290**		0.059	0.135
	(0.128)		(0.128)	(0.128)
Post change period		0.065		
		(0.045)		
2005 x below 5.5 m			0.022	
			(0.090)	
2006 x below 5.5 m			-0.041	
			(0.104)	
2007 x below 5.5 m			-0.048	
			(0.118)	
2008 x below 5.5 m			-0.058	
			(0.124)	
2009 x below 5.5 m			0.058	
			(0.126)	
2010 x below 5.5 m			0.178	
			(0.120)	
2011 x below 5.5 m			0.156	
			(0.117)	
2012 x below 5.5 m			0.278**	
			(0.122)	
2013 x below 5.5 m			0.309***	
			(0.117)	
Post change period x below 5.5 m				0.225***
				(0.059)
Constant	3.960***	1.983	4.007***	3.976***
	(1.013)	(1.786)	(1.000)	(0.998)
R-sq.	0.097	0.100	0.077	0.071
No. of obs.	4,310	4,310	4,310	4,310
No. of firms	797	797	797	797

Note: The dependent variable is Log Intramural R&D. Clustered standard errors at firm level in parentheses. All specifications include firm fixed effects. Sales and direct subsidies are instrumented with lagged sales and direct subsidies.

* p<0.10, ** p<0.05, *** p<0.01

Table 4.6 Short term additionality of SkatteFUNN for different levels of historic R&D investments

	(1) R&D > 1 m	(2) R&D > 2 m	(3) R&D > 3 m	(4) R&D > 4 m
Log Sales	0.313***	0.290***	0.220**	0.228**
	(0.086)	(0.084)	(0.090)	(0.098)
Log Direct	0.122***	0.063**	0.062**	0.072*
Subsidies	(0.036)	(0.028)	(0.032)	(0.039)
2005	0.332***	0.140	0.177*	0.193*
	(0.115)	(0.088)	(0.097)	(0.100)
2006	0.302**	0.137	0.170	0.200*
	(0.123)	(0.096)	(0.109)	(0.112)
2007	0.237**	0.089	0.140	0.179
	(0.118)	(0.098)	(0.112)	(0.118)
2008	0.259**	0.089	0.147	0.189
	(0.119)	(0.100)	(0.112)	(0.117)
2009	0.152	0.012	0.077	0.136
	(0.121)	(0.100)	(0.110)	(0.109)
2010	0.108	-0.034	0.007	0.047
	(0.120)	(0.101)	(0.110)	(0.116)
2011	0.123	-0.054	-0.004	0.036
	(0.124)	(0.105)	(0.116)	(0.121)
2012	0.084	-0.091	-0.038	-0.045
	(0.122)	(0.102)	(0.111)	(0.118)
2013	0.112	-0.068	-0.031	-0.010
	(0.125)	(0.104)	(0.116)	(0.128)
Post 2009 x	0.199***	0.133**	0.050	0.003
below 5.5	(0.060)	(0.059)	(0.066)	(0.092)
Constant	4.172***	4.921***	5.901***	5.940***
	(1.014)	(0.975)	(1.072)	(1.183)
R-sq.	0.074	0.058	0.066	0.061
No. of obs.	3,871	3,004	2,245	1,620
No. of firms	660	494	361	257

Note: The dependent variable is Log Intramural R&D. Clustered standard errors at firm level in parentheses. All specifications include firm fixed effects. Sales and direct subsidies are instrumented with lagged sales and direct subsidies.

* p<0.10, ** p<0.05, *** p<0.01

As Hægeland and Møen (2007), we have chosen to define the two groups of firms (above and below the cap) based on their average level of R&D investments prior to the increase in the cap. The classification of firms is more uncertain for firms with historical R&D investments close to the new cap of NOK 5.5 million (they may have some years with investments above the cap). Thus, the risk of misclassifying firms increases with the increase in the lower limit of historical R&D levels. Misclassifying firms will cause the measured difference to be smaller than the true difference (Hægeland & Møen, 2007, p. 16).

Setting an upper limit for average pre-change R&D investment for firms above the cap, with a similar difference to the cap as the lower limit, leaves us with an insufficient number of observations of firms above the cap. Excluding firms with average intramural R&D above NOK 10 million prior to the change in 2009, does not change the estimated effect for the post-change period significantly.

Considering our relatively modest estimates, it is worth noting that the limit for tax deductible R&D expenditures was mainly increased in 2009 to dampen the effect of the global financial crisis. The number of firms receiving an R&D tax credit in this period (2008-2009) is the lowest number of beneficiaries in the history of the scheme.

As pointed out by Hægeland and Møen (2007), several firms classified as having an incentive to increase their R&D investments, do not apply for a tax credit. To evaluate whether firms do more R&D than they otherwise would have done when receiving an R&D tax credit we compare growth rates among firms that self-select into the tax credit scheme by the following equation:

$$\begin{aligned}\ln(R\&D_{it}) = \alpha &+ \gamma \ln(sales_{it}) \\ &+ \chi \ln(subsidies_{it}) \\ &+ \sum_{t=1}^{t=T} \delta_t D^{year\ t} \\ &+ \sum_{t=1}^{t=T} \phi_t D^{year\ t} \\ &\times D^{BelowCap} \\ &+ \theta SF + \beta SF \times D^{BelowCap} \\ &+ \eta_i + \epsilon_{it}\end{aligned} \tag{4.3}$$

The coefficient SkatteFUNN, θ, is insignificant in all specifications reported in Table 4.7.

Table 4.7 Short term additionality of SkatteFUNN, controlling for participation in SkatteFUNN

	(1) Core sample R&D	(2) Core sample R&D	(3) Core sample FTEs	(4) Core sample FTEs
Log Sales	0.303***	0.304***	0.418***	0.415***
	(0.083)	(0.083)	(0.126)	(0.126)
Log Direct Subsidies	0.120***	0.124***	0.117**	0.117**
	(0.037)	(0.037)	(0.059)	(0.058)
2005	0.304***	0.359***	0.204	0.336*
	(0.102)	(0.115)	(0.145)	(0.174)
2006	0.311***	0.330***	0.254	0.406**
	(0.117)	(0.121)	(0.163)	(0.200)
2007	0.264**	0.278**	0.154	0.322*
	(0.123)	(0.116)	(0.156)	(0.188)
2008	0.289**	0.295**	0.161	0.311
	(0.124)	(0.118)	(0.154)	(0.207)
2009	0.250**	0.167	0.154	0.283
	(0.115)	(0.120)	(0.147)	(0.186)
2010	0.128	0.134	0.166	0.226
	(0.119)	(0.118)	(0.155)	(0.183)
2011	0.153	0.149	0.162	0.214
	(0.126)	(0.122)	(0.171)	(0.195)
2012	0.034	0.115	0.044	0.207
	(0.121)	(0.122)	(0.163)	(0.194)
2013	0.067	0.173	0.007	0.252
	(0.126)	(0.123)	(0.176)	(0.198)
2005 x below 5.5 m	0.058		0.188*	
	(0.091)		(0.113)	
2006 x below 5.5 m	0.008		0.218	
	(0.104)		(0.136)	
2007 x below 5.5 m	0.001		0.240*	
	(0.118)		(0.140)	
2008 x below 5.5 m	-0.010		0.215	
	(0.125)		(0.170)	
2009 x below 5.5 m	0.102		0.369**	
	(0.126)		(0.158)	
2010 x below 5.5 m	0.227*		0.272*	
	(0.119)		(0.154)	
2011 x below 5.5 m	0.215*		0.262*	
	(0.117)		(0.151)	
2012 x below 5.5 m	0.335***		0.418**	
	(0.121)		(0.164)	
2013 x below 5.5 m	0.367***		0.531***	
	(0.117)		(0.163)	
SkatteFUNN	0.006	0.010	-0.059	-0.049
	(0.062)	(0.062)	(0.057)	(0.056)
SkatteFUNN x below 5.5 m	0.246***	0.237***	0.365***	0.349***
	(0.072)	(0.072)	(0.087)	(0.085)
Post change period x below 5.5m		0.238***		0.184**
		(0.058)		(0.080)
Constant	3.987***	3.963***	-4.050***	-4.015***
	(0.974)	(0.974)	(1.471)	(1.467)
R-sq.	0.051	0.055	0.003	0.010
No. of obs.	4,310	4,310	4,310	4,310
No. of firms	797	797	797	797

Note: The dependent variable is Log Intramural R&D in column (1), (2), (5) and (6) and Log R&D FTEs in column (3) and (4). Clustered standard errors at firm level in parentheses. All specifications include firm fixed effects. Sales and direct subsidies are instrumented with lagged sales and direct subsidies.

* p<0.10, ** p<0.05, *** p<0.01

Our results do not suggest that all firms invest more in R&D with SkatteFUNN, than what they otherwise would have done. However, for firms that used to invest in R&D below the cap of NOK 5.5 million, the coefficient is significantly positive, for intramural R&D both in monetary terms and full-time equivalents. The estimated coefficient on the effect of SkatteFUNN for firms below the cap increases significantly if we include firms that reports zero R&D in some years prior to the increase in the cap.

Firms using SkatteFUNN and with pre-change R&D investments below NOK 5.5 million has had a higher growth in their R&D investment than firms that had relatively high R&D investment (no subsidies on the margin) for all restrictions on the sample (cf. Table 4.8). In line with the picture in Figure 4.3 the estimated effect is decreasing the more we restrict the sample. This is also the case in Hægeland and Møen (2007).

If the SkatteFUNN-coefficient captures a common self-selection effect, the coefficient for the interaction term (SkatteFUNN x below 5.5m) can be considered as the effect of the tax credit itself (Hægeland & Møen, 2007).

Like in the previous evaluation (Hægeland & Møen, 2007), we also find that firms investing less than the cap, increased their R&D expenditures more than those with investment above the cap, irrespective of whether they were beneficiaries of SkatteFUNN or not (interaction between the post change period and below cap in column (2), (5) and (6) in Table 4.7). This effect is also significantly positive when we measure R&D as intramural R&D. However, the effect is very small.

Table 4.8 Short term additionality of SkatteFUNN for different levels of historic R&D investments, controlling for participation in SkatteFUNN

	(1) R&D > 1m	(2) R&D > 2m	(3) R&D > 3m	(4) R&D > 4m
Log Sales	0.299***	0.288***	0.223**	0.227**
	(0.084)	(0.083)	(0.090)	(0.098)
Log Direct Subsidies	0.123***	0.064**	0.063**	0.071*
	(0.035)	(0.028)	(0.031)	(0.039)
2005	0.357***	0.158*	0.193**	0.194*
	(0.112)	(0.087)	(0.096)	(0.099)
2006	0.338***	0.163*	0.190*	0.202*
	(0.119)	(0.094)	(0.108)	(0.111)
2007	0.276**	0.117	0.159	0.180
	(0.114)	(0.096)	(0.110)	(0.117)
2008	0.297**	0.114	0.164	0.191
	(0.116)	(0.098)	(0.110)	(0.116)
2009	0.176	0.030	0.090	0.137
	(0.118)	(0.099)	(0.108)	(0.108)
2010	0.138	-0.011	0.024	0.050
	(0.116)	(0.100)	(0.109)	(0.115)
2011	0.159	-0.027	0.016	0.040
	(0.120)	(0.104)	(0.115)	(0.120)
2012	0.119	-0.069	-0.024	-0.043
	(0.119)	(0.101)	(0.110)	(0.118)
2013	0.150	-0.041	-0.011	-0.007
	(0.121)	(0.103)	(0.114)	(0.127)
SkatteFUNN	0.010	0.037	0.035	0.030
	(0.061)	(0.060)	(0.059)	(0.059)
SkatteFUNN x below 5.5	0.227***	0.182**	0.136*	0.048
	(0.072)	(0.072)	(0.080)	(0.094)
Post 2009 x below 5.5	0.215***	0.141**	0.054	0.003
	(0.059)	(0.057)	(0.065)	(0.092)
Constant	4.185***	4.817***	5.782***	5.930***
	(0.990)	(0.968)	(1.069)	(1.183)
R-sq.	0.049	0.035	0.040	0.056
No. of obs.	3,871	3,004	2,245	1,620
No. of firms	660	494	361	257

Note: The dependent variable is Log Intramural R&D. Clustered standard errors at firm level in parentheses. All specifications include firm fixed effects. Sales and direct subsidies are instrumented with lagged sales and direct subsidies.

* p<0.10, ** p<0.05, *** p<0.01

4.3.4 Probability to start or continue R&D

In the analysis above, we only included firms that reported positive R&D prior to the increase in the cap in 2009. We now want to study whether the increase in the cap affected the probability to start investing in R&D (i.e. effect of the scheme at the extensive margin). Again, following Hægeland and Møen (2007), the estimation of the probability to start doing R&D is done as a separate analysis, based on the argument that the decision to start doing R&D for the first time is different from deciding how much R&D to do.

Hægeland and Møen (2007) found that in 2003 and 2004, i.e. the first two years after the introduction of SkatteFUNN, firms that did not invest in R&D two years earlier had 6-7 percentage points higher probability of starting to invest in R&D, compared to the years between 1995 and 2001. Furthermore, they find that this positive effect is not present in 2005. Their interpretation is that the pool of potential R&D performers among those that did not previously invest in R&D seems to become increasingly exhausted.

If the abovementioned interpretation holds, there is reason to believe that there is no, or at least moderate, effect on the probability to start investing R&D of the increase in the cap in 2009. Furthermore, if firms have not already started doing R&D in the presence of a scheme offering tax credit on intramural R&D up to NOK 5.5 million and total R&D costs up to NOK 8 million, it seems unlikely that increasing the limits will affect their propensity to start doing R&D.

Including firms that have never invested in R&D in the sample and estimating the probability to start doing R&D, given that the firm did not do R&D two years earlier, confirms our assumptions. We find no significant change in the probability to start doing R&D after the increase in the cap (cf. Table 4.9).

Table 4.9 Probability of starting or continuing R&D

	Intramural $R\&D_{t-2} = 0$	Intramural $R\&D_{t-2} > 0$
Log Sales	0.022***	0.028**
	(0.006)	(0.012)
Log $Sales_{t-2}$	-0.011**	-0.032***
	(0.006)	(0.012)
2010[1]	-0.005	0.043***
	(0.008)	(0.013)
2011[1]	-0.009	0.051***
	(0.009)	(0.013)
2012[1]	-0.001	0.056***
	(0.009)	(0.013)
2013[1]	0.017*	0.074***
	(0.010)	(0.013)
Pseudo R-sq.	0.007	0.008
No. of obs.	10,728	7,196
No. of firms	4,230	1,982

1) Marginal effect for discrete change of the dummy variable from 0 to 1. The years 2003-2009 are absorbed by the constant term and not reported. Clustered standard errors at firm level in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

Looking at the probability of continuing to do R&D, given that a firm did R&D two years ago, we find significantly positive effects that increases for each year in the period after the change in 2009. Thus, the probability of continuing to do R&D increased after the limit for tax-deductible R&D expenditures increased, compared to the period prior to the increase.

4.3.5 Expanded R&D information

If we combine the data from the R&D surveys with information on firms' R&D expenditures from SkatteFUNN applications and information on R&D grants, we get similar results as the ones reported above. However, including information on R&D investment from these additional sources, decreases the number of observations in the sample. This is because some firms report zero R&D in some years in the extended data, whereas information on R&D investment is missing for the same years in the R&D surveys. Firms that at one point in time report zero R&D are excluded from our sample.

Hægeland and Møen (2007) stress the importance of reported zeros in their analysis and whether these are true zeros or not. Additional sources of information on firms' R&D activity suggest that some of the reported zeros are indeed zero and some are not. Given our definition of the sample, and that the results are relatively robust to the expansion of the data, we are less concerned about firms reporting zero R&D.

4.3.6 Bang for the buck

In assessing the success of the scheme, we need to know how much additional R&D has been induced per krone spent on the scheme. That is, we want to estimate the so-called "bang for the buck" (BFTB).

For reference, a project that would not have been undertaken at all without the R&D tax credit will have a BFTB of $\frac{1}{0.20} = 5$ if an SME and $\frac{1}{0.18} = 5.56$ for other firms (cf. chapter 2.2.1).

A project that would have been undertaken in full, without the tax credit, will have a BFTB of zero. Typically, a BFTB of 1 or slightly more is considered acceptable (Hægeland & Møen, 2007, p. 46).

We first estimate the BFTB based on estimated effects for the core sample, i.e. we use our estimated change in R&D investment induced by a firm below the cap receiving an R&D tax credit. With the specification above, the expected value of the counter factual R&D investment, in absence of a tax credit for a firm below the cap is:

$$\ln(R\&D_{it}^{without\ tax\ credit}) = \ln\left(R\&D_{it}^{with\ tax\ credit}\right) - \beta$$

Following Hægeland and Møen (2007), we calculate the counterfactual R&D investment for all firms in the sample below the cap, with an R&D tax credit, and summarise the difference between this and each firm's observed R&D investment. Doing this we get additional R&D investment of NOK 1,270,760. Furthermore, we summarise the R&D tax credit received by all firms in the sample, both firms above and below the cap, and get NOK 1,260,910. The former divided by the latter gives an estimated BFTB for the firms in our sample of 1.01. That is, for each krone given in tax credit one gets one krone in additional R&D.

The estimated BFTB reported above is significantly lower than what Hægeland and Møen (2007) get with the same approach. However, our sample only include firms that always report positive R&D investment in the R&D surveys. If we include firms that in some years prior to the change report zero R&D, the estimated BFTB is 4.4.

If we restrict the sample of firms below the cap to firms with average intramural R&D prior to the change above NOK 1 million, we get an estimated BFTB of 0.96. Restricting the sample to firms with average R&D above NOK 2 million in the years prior to the change further reduces the BFTB to 0.73.

Given these discrepancies, it is important to keep in mind that the estimates are proven to be sensitive to sample restrictions and model specifications. In addition, the sample used is not representative for the true composition of firms participating in the scheme (Hægeland & Møen, 2007, p. 47). When the sample is restricted to firms that are included in the R&D surveys, and in addition must report positive R&D every year they participate in the survey, our sample is restricted to large firms measured in number of employees. Average number of employees for firms in the sample is 115. Thus, the estimated BFTB of 1.01 must be seen as an estimate for relatively large (and experienced) R&D performers. We present estimates for a more representative sample of SkatteFUNN beneficiaries below.

4.4 Estimation of input additionality by generalized difference-in-difference approach

In this section we use a "generalized difference-in-difference" approach with matching to study the variation in additionality across different generations of SkatteFUNN-beneficiaries under different policy regimes. This approach confirms a positive and strongly significant input additionality of SkatteFUNN. The overall BFTB measure in the main model is 2.07. However, the BFTB varies across generations and policy regimes. For all generations, input additionality is strongest when they start using SkatteFUNN and declines with time. The only exception is the policy changes in 2014 and 2015, where the additionality is higher.

As described in chapter 2.2.4, there has been made several changes in the scheme after its introduction in 2002. In the previous chapter we exploited the increase in the cap of the tax-deductible amount in 2009. In this chapter we use the method of generalised difference-in-difference to analyse all changes.

The main advantage of the generalised difference-in-difference method is that it allows evaluation of all changes in SkatteFUNN. With this method, we evaluate how the input additionality of SkatteFUNN varied under different policy regimes. Moreover, we compose generations of SkatteFUNN-beneficiaries and follow their R&D investment behaviour under different policy regimes.

The approach applied follows the one used by Mohnen et al. (2017). Mohnen et al. (2017) evaluated the innovation box tax policy instrument in the Netherlands. The rules and conditions of this policy changed annually during the evaluation period of 2007-2013, making it difficult to isolate the effect of one change in the policy from another. SkatteFUNN has also changed several times, but the changes in the scheme have not been annual. The changes allow us to evaluate the input additionality of the whole scheme and identify each change's effect on firms' R&D investment.

4.4.1 Introducing the method

The difference-in-difference method is typically implemented in a situation with two periods, e.g. one with and one without the policy or one before the change and one after. The regression used in this case is following:

$$Y_{it} = b_0 + b_1 D^1 + b_2 S_i + b_3 D^1 S_i + \sum_j \beta^j X_{it}^j + \varepsilon_{it} \quad (1)$$

Here, Y_{it} is the dependent variable on which we measure the effect of SkatteFUNN (R&D expenditures in our case), and X_{it}^j is a range of control variables. D^1 is a dummy-variable equal to 1 for the period after treatment (when the policy is implemented or after a change) and 0 for the period before treatment (when the policy does not exist or before a change). S_i is an indicator for policy beneficiaries, i.e. a dummy variable equal to 1 if the firm has used SkatteFUNN in any year after introduction of the policy and 0 for the control group of firms that have not used the policy.

The estimated parameter $\boldsymbol{b}_0$ measures the average outcome (in terms of Y_{it}) for the control group in period 0. $\boldsymbol{b}_0+\boldsymbol{b}_1$ is the average outcome for the control group in period 1. $\boldsymbol{b}_2$ is the difference between the control group and the policy beneficiaries in period 0, i.e. the difference before the policy is implemented or changed. $\boldsymbol{b}_0+\boldsymbol{b}_2$ is the average outcome for beneficiaries in period 0, while $\boldsymbol{b}_0+\boldsymbol{b}_1+\boldsymbol{b}_2+\boldsymbol{b}_3$ is the average outcome for these firms in period 1. The difference in outcome for beneficiaries between period 0 and period 1 is therefore $\boldsymbol{b}_1+\boldsymbol{b}_3$. Of this, $\boldsymbol{b}_1$ is identical to the difference for the control group. Hence, $\boldsymbol{b}_3$, which is the difference-in-differences,

measures the 'additionality' of the policy, i.e. the extra R&D performed as a result of the policy.

If there had been no changes to the scheme, we could use the simple model. However, due to several changes, we need to apply a difference-in-differences method with more than one period. We then use the following specification, where equation (1) is transformed to a multiple period case:[65]

$$Y_{it} = \gamma^0 + \sum_{T \neq 0} \gamma^T G_i^T + \sum_T \tau^T D^T + \sum_{T_0} \sum_{T_1 \geq T_0} \alpha^{T_0 T_1} G_i^{T_0} D^{T_1} g_{it} + \sum_j \beta^j X_{it}^j + \varepsilon_{it} \quad (2)$$

Here**,** T is a categorical variable that can be equal to 0, 1, 2, 3, etc. depending on the total number of periods**.** G^T is an indicator for user-generation. D^T is a dummy variable for period T, while g_{it} is a dummy variable that indicates whether firm ***i*** uses the policy in period ***t***. T_0 represents the period before the first use of the policy, and T_1 any other period after this.

The parameters *γ*, τ, *α* and *β* are estimates. The *γ* parameters correct for differences between policy beneficiaries and non-beneficiaries before treatment, to the extent that these differences are not reflected in the set of variables X.

As pointed out by Mohnen et al. (2017), the use of multiple *γ* parameters enables separation of different categories of beneficiaries, such as early and late adopters of the policy (non-beneficiaries will have zero value for all ***G*** variables). In other words, we allow firms that commence using SkatteFUNN immediately after it has been introduced differ from firms that start using the policy later (possibly encouraged by the specific policy change).

The τ parameters correct for differences between defined policy regimes. Because, as discussed earlier, there were several changes in SkatteFUNN, it is important to account for these differences.

Finally, the *α* parameters measure the effect of SkatteFUNN. Instead of just a single effect, we estimate one effect for each combination of user-generation (***G***) and period (*T*). For example, the parameter $\alpha^{1,3}$ would measure the effect of the policy in period 3 on firms from the first user generation (those who started to use the policy just after its introduction). A similar parameter (effect) is then estimated for every possible combination of period and generation.

4.4.2 SkatteFUNN policy regimes and user generations

Before we move to the estimates of the model (2), we need to define the policy regimes. Data for this evaluation are available for the period 1999-2015. SkatteFUNN was introduced in 2002 for SMEs only, but already in 2003 it was expanded to all firms.

Figure 4.5 shows how many firms commenced using SkatteFUNN annually. We observe that the scheme was most popular among new beneficiaries just after introduction. After the introduction, the number of new beneficiaries declined until 2009. However, the number of new beneficiaries has increased since.

We define the first policy regime to be 2002-2003, i.e. the period just after introduction of the scheme that comprises "early" beneficiaries of SkatteFUNN. Furthermore, we want to account for the changes in

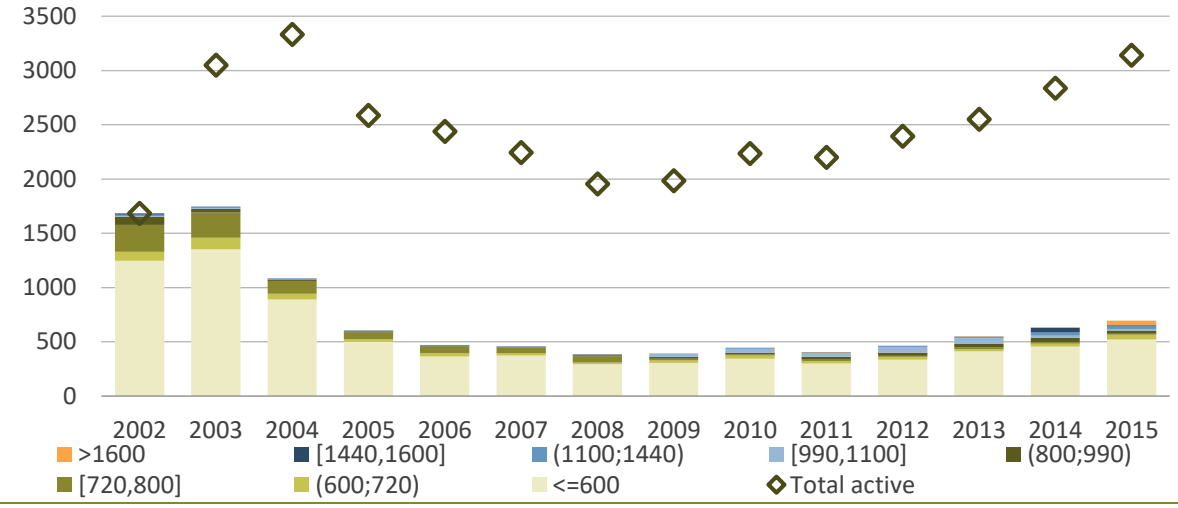
[65] We follow here the model specification (2a) in Mohnen et al. (2017) that assumes a short-term effect of the policy use on R&D dependent variable, i.e. when the effect is limited to the time period in which the use of the policy occurs. Another specification used Mohnen et al. (2017) assumes that the firm will always have an effect as a result of a one-period use of the policy. While innovation box tax credit is applied to the output of possibly quite long R&D effort, SkatteFUNN tax credit yields R&D expenditures in the given year and the average project length is 2 years. Hence, we prefer to use here the former model specification.

the project cost cap that took place in 2009, 2014 and 2015.

Figure 4.6 demonstrates the share of SkatteFUNN beneficiaries by tax credit size. We can observe that most of the beneficiaries have never reached the project cost cap (their share was about 80 per cent in 2002 and fell to about 60 per cent in 2015). Furthermore, SkatteFUNN beneficiaries reaching the project cost cap early, increased their R&D investment to the new levels after extensions in 2009, 2014 and 2015. Very few "new" beneficiaries have R&D expenses enabling the maximum tax credit, cf. Figure 4.5.

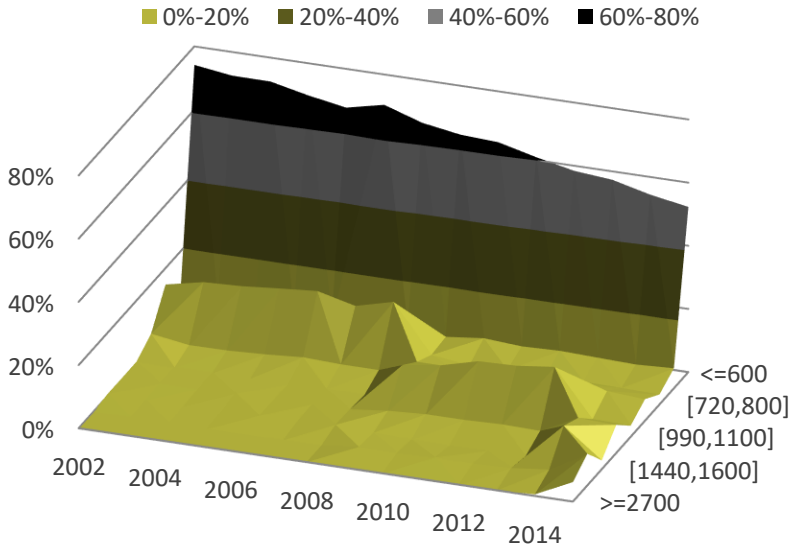
The tax credit rate has so far been unchanged during the whole period of SkatteFUNN existence (20 per cent for SMEs and 18 per cent for others).

Figure 4.5 Number of new SkatteFUNN users by tax credit size and number of active users.



Source: Samfunnsøkonomisk analyse AS and Statistics Norway

Figure 4.6 Transition of SkatteFUNN beneficiaries from one top to another after changes in 2009 and 2014-2015. Share of beneficiaries by tax credit size. In thousand NOK.



Source: Samfunnsøkonomisk analyse AS and Statistics Norway

In addition to the changes in the threshold for R&D tax credit, the rules of SkatteFUNN were changed in 2007 and 2011. The former change introduced additional caps on hourly wages and annual hours for calculation of project costs. While new definitions of R&D and SMEs were implemented in 2011. Both changes could affect firms' R&D behaviour and their willingness to apply for SkatteFUNN.

As a result, we end up with six policy regimes and six SkatteFUNN-user generations correspondingly; 2002-2003, 2004-2006, 2007-2008, 2009-2010, 2011-2013 and 2014-2015. The first comprises early adopters of a new policy, the second cover the period before the 2007-change, third before the 2009-change, forth before the 2011-change, firth before the changes in 2014-2015 that we grouped in the final, sixth group.

4.4.3 Construction of variables

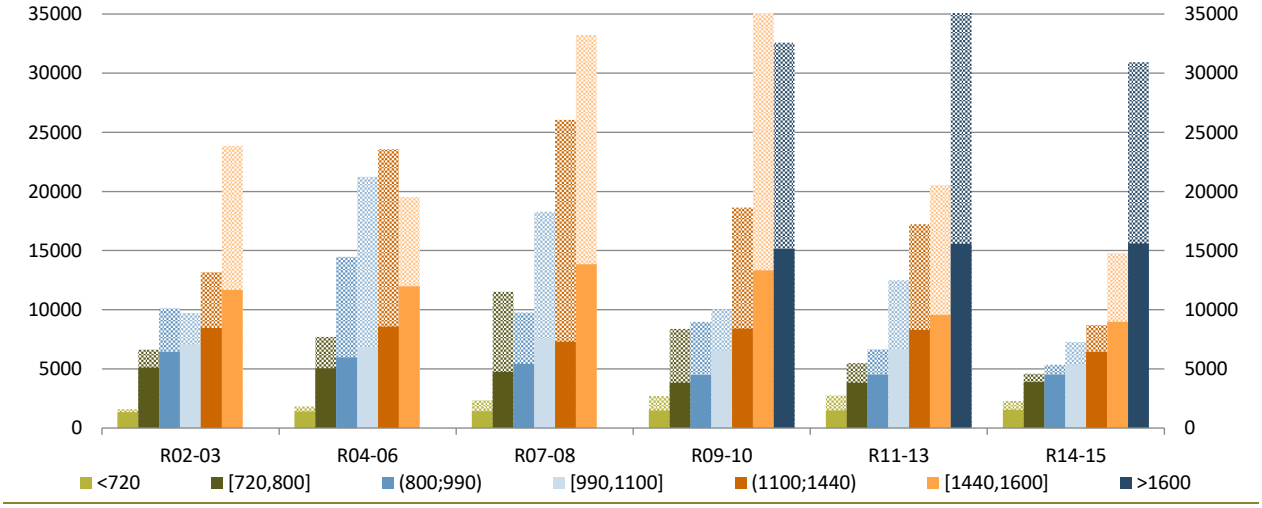
Dependent variable (*Y* in equation 2): total R&D expenditures (log)

As was pointed out in chapter 4.2, only 30 per cent of the observations on SkatteFUNN firms are present in R&D surveys between 2002 and 2015. We therefore utilize all available information on R&D expenditure from other sources. These sources are SkatteFUNN data on R&D expenditures that are eligible for SkatteFUNN from the Tax Administration, data on R&D expenditures three years prior to SkatteFUNN application from RCN, and data on R&D grants and other public support for R&D from our own database.

Figure 4.7 compares data on R&D expenditures reported to the Tax Administration with the extended measure of R&D expenditures (cf. chapter 4.2 for details of construction of this measure). We can observe that SkatteFUNN beneficiaries tend to report only the part of their R&D eligible for the tax credit, and not the full R&D expenditure to the Tax Administration.

While Mohnen et al. (2017) use information from their WBSO/RDA tax credit scheme, observing such a large underreporting of R&D expenditures to the Norwegian Tax Administration, we prefer to use the extended R&D measure for the further analysis.

Figure 4.7 Average R&D expenditures by data source, tax credit size and SkatteFUNN-regimes. The dark area shows the R&D expenditures as reported to the tax authorities, while the light area shows the R&D expenditures as identified from other data sources. In thousand NOK.



Source: Samfunnsøkonomisk analyse AS, Tax authorities and Statistics Norway

Control variables (*X* in equation 2)

Our control variables are described below.

- ***Firm size****: number of employees (log, log^2).* Large firms tend to invest more often and more in R&D, than small firms.
- ***Liquidity constraint****: current assets/short-term debt (log).* Many studies have documented that a firm's ability to innovate is affected by the availability of own funds. We would therefore expect constrained firms to be less involved in R&D activities and more active in searching R&D support.
- ***Tax liability****: dummy variable for firm being tax liable*. This variable is 1 if the firm pays taxes and 0 if not and is another indicator of firms' financial constraints.
- ***Share of high-skilled employees****: Share of man-hours worked by employees with at least upper secondary education.* This variable is very often used in R&D and innovation related analyses since firms need to have qualified personal to do R&D.
- ***R&D support from other sources****: direct subsidies (log).* As shown in chapter 7, SkatteFUNN is the only source of R&D support for about 65 per cent of SkatteFUNN beneficiaries (if we look at schemes with similar objectives). However, the remaining 35 per cent of firms use other sources of public support. Hence, we need to control for this to isolate the impact of SkatteFUNN.
- ***Past R&D experience****: dummy variable for positive R&D in at least one year during the previous three-year period.* There is a large persistency in doing R&D, hence, firms with recent R&D experience will have higher probability of doing R&D, than firms without such an experience. For newly established firms (0-1 years old) this dummy is set to zero (if positive R&D is not observed).
- ***Other firm characteristics****: firm location and industry dummies.* These are included to account for regional and industry specific differences.
- ***Time dummies****:* These are included to account for time-specific effects and macro shocks that are not covered by policy regime dummies (i.e. the financial crisis in 2008-09).

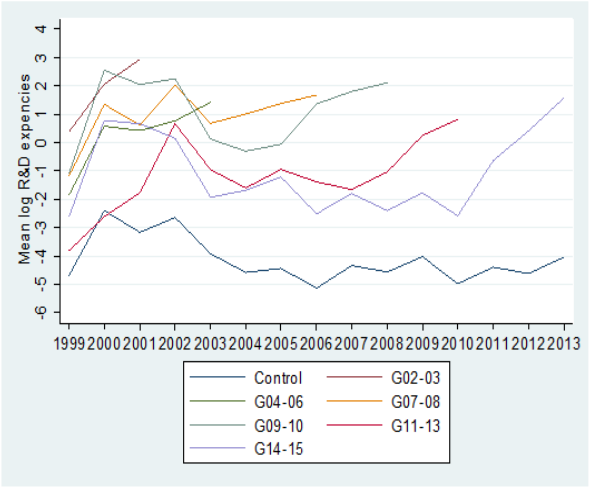
4.4.4 Estimation strategy - Difference-in-difference with matching

The last step we need to do before moving to estimation of equation (2), is to test the identifying assumption for using diff-in-diff, i.e. the common trends assumption. Changes in the behaviour of SkatteFUNN beneficiaries can only be claimed due to SkatteFUNN if the development of R&D expenditure in the treatment and control is similar before treatment, rather than determined by observable and unobservable characteristics.

Discrepancies in R&D investment between the groups is often the case when the beneficiaries are not randomised. For example, the decision to apply for SkatteFUNN may be based on the (unobserved) probability of success for already ongoing projects. Also, for firms that already are engaged in R&D activities it is easier to apply for R&D subsidies. Ignoring such self-selection mechanisms may lead to seriously biased estimates of causal effects.

As demonstrated by the previous evaluation, firms with R&D and collaboration experience, a high share of employees with academic education and/or financial constraints have a larger probability of applying for SkatteFUNN than other firms (Cappelen et al., 2012). Furthermore, Figure 4.8 shows that different SkatteFUNN-user generations have a positive increase in their R&D expenditures just prior to the start of SkatteFUNN use, demonstrating a deviation from the development trend in R&D expenditures by other firms.

Figure 4.8 Average R&D expenditures for different SkatteFUNN-user generations and other firms in the corresponding pre-reform period.



Source: Samfunnsøkonomisk analyse AS

Also, the formal test of the common trends assumption (CTA) for different generations of SkatteFUNN beneficiaries demonstrate violation of this crucial assumption when we compare them to other firms prior to the start of their SkatteFUNN use.

For the formal test we estimate the following equation for each generation separately:

$$Y_{it} = \gamma^0 + \gamma^1 G_i^T + \sum_{k\geq 1} \tau^{T_{1-k}} D^{T_{1-k}} + \sum_{k\geq 1} \alpha^{TT_{1-k}} G_i^T D^{T_{1-k}} + \sum_j \beta^j X_{it}^j + \varepsilon_{it}. \quad (3)$$

Here, Y_{it} is R&D expenditures (in log), G^T is an indicator variable for SkatteFUNN-beneficiaries that start using the policy under regime *T=1,2,3,4,5,6* and X_{it}^j is a range of control variables, as in equation (2). T_1 represents the first year of a corresponding regime, T_{1-k} with $k \geq 1$ covers as many pre-reform periods as possible and $D^{T_{1-k}}$ is a dummy-variable equal to 1 for period T_{1-k}.

We would like to estimate $\alpha^{TT_{1-k}}$. For example, for the first user generation (T=1 and T_1 = 2002), we would like to estimate αs for the years before 2002, i.e. for 2000 and 2001 with 1999 being a reference year. For the second user generation (T=2 and T_1 = 2004) we would like to estimate αs for the years before 2004, i.e. for 2000, 2001, 2002 and 2003 with 1999 as the reference year, and so on (in a total of six regressions). We then check whether each $\alpha^{TT_{1-k}}$ is statistically different from zero or not. The results reported in Table C1 of Appendix C do not confirm validity of CTA, demonstrating positive and highly significant αs in the years just before the start of SkatteFUNN use. Hence, we obviously have a self-selection of R&D active firms into the scheme and applying diff-in-diff for comparing all SkatteFUNN-beneficiaries with all non-beneficiaries will give us biased estimates.

One approach to the self-selection problem is propensity score matching. This approach is widely used in the evaluation literature[66] and is based on the idea that a treated firm and a nontreated firm can be matched if the probability of participating in the program is identical, given a vector of exogeneous covariates, *X*. The difference in the response variable *Y* can then be calculated for all matched pairs and the average value of these differences is a valid estimator of the average treatment effect among the treated.

Before matching, it is important to understand why some eligible firms do not apply for SkatteFUNN. Our interviews reveal that firms perceive four types of barriers to SkatteFUNN. First and foremost, firms receive the financial support from SkatteFUNN ret-

[66] See e.g. Almus and Czarnitzki (2003) who apply matching to study the effect of public R&D subsidies in Easten Germany and Freitas, et al. (2017) who apply matching to study effects of tac credit programs in France, Italy and Norway.

roactively and thus must wait for up to a year to receive it (which may place strain on the liquidity of an SME). Secondly, the financial incentive is considered rather small and the maximum hourly rate is considered too low. Thirdly, many firms are uncertain of whether they are eligible for SkatteFUNN and are unfamiliar with the terminology used, such as what qualifies as R&D. Fourthly, many SMEs state that their administrative capacity is a limitation.

The two latter types of barriers can partly explain why a third of SkatteFUNN beneficiaries engage consultants to write the application, which means that they are slower in building internal experience and that the financial incentive is further reduced. We note that these barriers are seldom voiced by firms that have prior experience of public R&D funding, which in contrast state that SkatteFUNN indeed is very easy to use. We may then conclude that the main reason firms do not use SkatteFUNN is likely a blend of ignorance and misconception about the administrative burden, which could be reduced through additional information campaigns.

We apply matching with stratification, following a similar procedure as in Cappelen et al. (2015), where in addition to specification of cells based on the firms' industry, region and cohort, we include an indicator of whether the firm has used other public support or not.[67] In that case we match beneficiaries to firms from the same industry and region, established at the same year and with a corresponding indicator on the use of other types of public support, but that have never participated in SkatteFUNN.

Our choice of matching variables within each cell is inspired by Blanes and Busom (2004), who study participation in R&D subsidy programs for Spanish manufacturing firms and by Cappelen et al. (2012), who study participation in SkatteFUNN. Like them, we include measures of the firm size, R&D experience, availability of skilled employees as well as firm's financing constraints. More specifically, our matching variables comprise firm size measured by total assets and number of employees, the share of employees with higher education, the financial liquidity rate (defined as current assets divided by short-term debt) and an indicator for previous R&D experience (during last three-year period).[68]

The availability of the latter variable restricts the entire population of firms considerably, so we do the alternative matching without an indicator for R&D experience. The results of the first matching (controlling for R&D experience) are used as our main specification. While the results from the second matching (not controlling for R&D experience) are used as a robustness check. In any case we control for the previous R&D experience when estimating the diff-in-diff model (2).

As stressed by Blundell and Costa Dias (2009) and pointed out by Cappelen et al. (2015), the matching variables must be determined before a unit potentially *can* be assigned to treatment (not just before it actually *is)*. This is a large problem when the time of treatment is not a fixed date, as in the case of tax credit use. Our matching variables are measured in 2000 or at the start-up year for firms established later (but before they start using SkatteFUNN). As a result, most SkatteFUNN beneficiaries are matched two years before introduction of SkatteFUNN. Such timing of our matching variables allows us to consider them predetermined.

Table 4.10 reports firm characteristics for SkatteFUNN and control firms before and after the matching procedure without controlling for the past R&D

[67] This indicator comprises R&D support from RCN, regional research funds and through EU-programs, as well as through an innovation assignment from Innovation Norway.

[68] We use the STATA routine *psmatch2* with 1 to 5 nearest neighbor matching with trimming. The option specification used is: *neighbor (5) common trim (10).*

experience, while Table 4.11 reports firm characteristics before and after the matching procedure when controlling for the previous R&D experience.

We observe that SkatteFUNN firms are larger (both measured by number of employees and total assets), more mature, have a higher share of high-skilled employees, their financial liquidity is lower, and they do more often use other types of support than firms not using SkatteFUNN. As was also demonstrated in chapter 2.4, SkatteFUNN-beneficiaries are overrepresented in ICT, technical services and manufacturing.

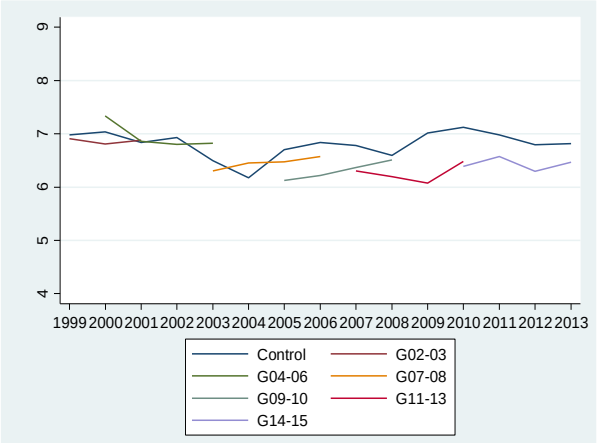
Table 4.10 also shows the number of firms before matching (the entire population) and after matching. The total population numbered 9,284 SkatteFUNN beneficiaries and 335,618 firms that have not used SkatteFUNN between 2002 and 2015.

After matching without controlling for past R&D experience we end up with 5,241 SkatteFUNN beneficiaries (about 33 per cent of the entire population of beneficiaries) and 19,822 control firms with the same regional and industrial distribution, with similar organizational age, financial liquidity rates and share of high-skilled employees in the start of their observational period. However, we failed to successfully match the firms by their size, i.e. SkatteFUNN beneficiaries are still significantly larger in terms of number of employees and slightly larger in terms of total assets.[69] However, the difference is much lower than between beneficiaries and non-beneficiaries.

If we use past R&D experience as an extra control variable under matching (cf. Table 4.11), we start with 7060 SkatteFUNN beneficiaries and 227,934 firms that have not used SkatteFUNN during 2002-2015. Note that a high share of the firms in the latter group are newly established, i.e. their average age is less than one year. After matching with controlling for the past R&D experience we end up with 3,089 SkatteFUNN beneficiaries (about 56 per cent of the entire population of beneficiaries) and 11,199 control firms. According to our tests the control firms are not significantly different now from the matched SkatteFUNN firms with respect to the chosen characteristics[70]

It is worthwhile noting that in both cases we end up with smaller SkatteFUNN beneficiaries than firms in the entire population, as it is hard to find a good match for the largest firms. That is what we can call the “price” of employing this method, i.e. we get reliable results, but for a smaller sample of firms, which might be less representative for the whole group of treated firms.

Figure 4.9 Average R&D expenditures for different SkatteFUNN-user generations and other firms in the corresponding pre-reform period. In thousand NOK.



Source: Samfunnsøkonomisk analyse AS

When we group firms with respect to their size as operationalized by the scheme[71] and compare their distribution before and after matching, we find that

[69] We use STATA command pstest to test whether means for each separate variable significance of

[70] H0: that a set of means is equal between two groups is not rejected by Hotelling test, cf. F-test presented at the bottom of the Table 4.11..

[71] I.e. the SMEs who get 20 per cent deduction and large firms who get 18 per cent deduction.

this distribution is only slightly changed. While there were 86 per cent SMEs among beneficiaries in the entire population, their share after matching have become 89 per cent. Therefore, we argue that our estimation results by the difference-in-difference method combined with matching will be applicable for the majority, but not the largest SkatteFUNN firms.

We also conduct visual and formal tests of CTA for the sample of matched firms. These tests provide evidence that both groups of firms now have similar development in their R&D expenditures in the pre-reform periods (jf. Figure 4.9 and Table C2 in Appendix C).

Given, however, a smaller sample and shorter time-series before SkatteFUNN participation due to the restricted information on the past R&D experience; we provide these tests only for the four-year pre-reform periods.[72] All αs reported in Table C2 of Appendix C are not significantly different from zero. Hence, we can proceed now to estimation of model (2) on the matched sample.

Table 4.10 Firm characteristics before and after matching procedure. Population of all firms.

		Before matching				After matching		
Variables	SKF-firms	not SKF-firms	%bias		SKF-firms	not SKF-firms	%bias	
No. of employees	29.54	3.62	11.8	***	10.12	8.11	7.70	***
Total assets	80799	14830	6.6	***	18901	11845	3.80	*
Organisational age	5.10	3.89	12.6	***	5.87	5.96	-0.8	
Share of high-skilled	0.36	0.14	63.5	***	0.33	0.32	0.10	
Financial liqudity rate	31.70	68.09	-17.9	***	32.18	33.85	-1.00	
Dummies:								
Other types of support	0.27	0.004	84.2	***	0.04	0.04	0	
Bioeconomics	0.10	0.03	29.6	***	0.10	0.10	0	
Mining&quarrying	0.01	0.005	7.2	***	0.003	0.003	0	
Tech. manufacturing	0.11	0.01	41.1	***	0.11	0.11	0	
Other manufacturing	0.08	0.02	29.1	***	0.06	0.06	0	
Construction	0.04	0.12	-32.4	***	0.03	0.03	0	
Retail trade	0.11	0.19	-22.5	***	0.14	0.14	0	
Transport	0.02	0.04	-14.3	***	0.01	0.01	0	
Tourism	0.01	0.05	-23.8	***	0.01	0.01	0	
Media	0.05	0.01	20.3	***	0.04	0.04	0	
ICT	0.15	0.03	45.1	***	0.17	0.17	0	
Professional and scientific activities	0.11	0.34	-57.7	***	0.12	0.12	0	
Tech. services	0.12	0.04	32.1	***	0.12	0.12	0	
Business-oriented services	0.04	0.05	-4.1	***	0.04	0.04	0	
Education	0.01	0.01	-2.0	*	0.00	0.00	0	
Helth	0.01	0.03	-12.0	***	0.00	0.00	0	
Other service activities	0.04	0.03	4.4	***	0.03	0.03	0	
Capital region	0.27	0.30	-7.1	***	0.31	0.31	0	
East-Norway	0.19	0.23	-9.3	***	0.21	0.21	0	
Souht	0.17	0.15	6.0	***	0.16	0.16	0	
West	0.20	0.17	7.7	***	0.20	0.20	0	
Mid-Norway	0.10	0.07	10.1	***	0.07	0.07	0	
North	0.07	0.08	-3.6	***	0.06	0.06	0	
No. firms	9284	335618			5241	19822		
F-test		3215.38***				1.70**		

[72] I.e. for each user generation we estimate equation (3) with k=1,2,3 and T_1-4 being a reference year.

Table 4.11 Firm characteristics before and after matching procedure. Population of firms with information on R&D in previous three-year period.

		Before match				After match		
	SKF-firms	not SKF-firms	%bias		SKF-firms	not SKF-firms	%bias	
No. of employees	21.98	2.64	36.1	***	10.71	10.07	2.2	
Total assets	77882	14261	5.8	***	14089	12304	2.9	
Organisational age	3.35	0.45	44.4	***	3.08	3.06	0.2	
Share of high-skilled	0.36	0.13	68.5	***	0.31	0.30	2.7	
Financial liqudity rate	36.62	81.42	-20.3	***	42.49	44.86	-1.2	
Dummies:								
Recent R&D experience^	0.15	0.002	58.0	***	0.04	0.03	9.4	***
Other types of support	0.30	0.004	90.2	***	0.02	0.02	0	
Bioeconomics	0.09	0.02	28.6	***	0.09	0.09	0	
Mining&quarrying	0.01	0.00	7.6	***	0.00	0.00	0	
Tech. manufacturing	0.11	0.01	43.1	***	0.10	0.10	0	
Other manufacturing	0.08	0.01	32.4	***	0.06	0.06	0	
Construction	0.03	0.13	-38.9	***	0.02	0.02	0	
Retail trade	0.09	0.16	-20.3	***	0.12	0.12	0	
Transport	0.01	0.03	-14.6	***	0.00	0.00	0	
Tourism	0.01	0.05	-25.6	***	0.00	0.00	0	
Media	0.05	0.01	21.7	***	0.04	0.04	0	
ICT	0.18	0.03	49.4	***	0.23	0.23	0	
Professional and scientific activities	0.11	0.37	-63.2	***	0.14	0.14	0	
Tech. services	0.13	0.03	35.2	***	0.12	0.12	0	
Business-oriented services	0.04	0.05	-3.9	**	0.04	0.04	0	
Education	0.01	0.01	-2.9	***	0.00	0.00	0	
Helth	0.01	0.03	-13.5	***	0.01	0.01	0	
Other service activities	0.04	0.03	3.2	***	0.02	0.02	0	
Capital region	0.27	0.29	-5.0	***	0.32	0.32	0	
East-Norway	0.19	0.23	-10.2	***	0.20	0.20	0	
Souht	0.18	0.16	5.9	***	0.17	0.17	0	
West	0.19	0.16	6.6	***	0.20	0.20	0	
Mid-Norway	0.11	0.08	10.4	***	0.05	0.05	0	
North	0.07	0.08	-5.0	***	0.05	0.05	0	
No. firms	7060	227934			3089	11199		
F-test		3418.44***			1.2			
^ An indicator variable for R&D>0 in the previous 3-year period. It is assumed to be zero for any new established firm.								

4.4.5 Estimation results

Table 4.12 documents the estimated α parameters for the policy effects from model (2). To save space, other estimated parameters are not documented here (the full results for the main model are reported in Appendix C, cf. Table C3).[73]

We report two sets of results, one after the matching procedure without controlling for the past R&D experience, and another after matching using past R&D experience as an extra control variable.

We also report results from three specifications for each case of diff-in-diff estimation, i.e. where the indicator for past R&D experience is not included in

[73] In Table C3 we also check the robustness of our main results with respect to restriction of the sample to SkatteFUNN beneficiaries only, i.e. whether we exclude or not beneficiaries of other public schemes. Given that after matching only 2 per cent of SkatteFUNN firms have also used other sources of public support (cf. Table 4.11), such restriction of the sample has not influenced the main results significantly. Hence, we proceed further with our main model specification.

the set of control variables *X,* where it is included and where the sample of firms is restricted to the firms with positive past R&D experience only.

We find positive and significant effects of SkatteFUNN on R&D expenditures for all specifications and combinations of user-generations and policy regimes with only one exception. Namely, for the 2007-2008 generation under regimes 2009-2010 and 2011-2013. This indicates that most specified user-generations carried out more R&D than the control group, or, in other words, that SkatteFUNN did result in more R&D investment.

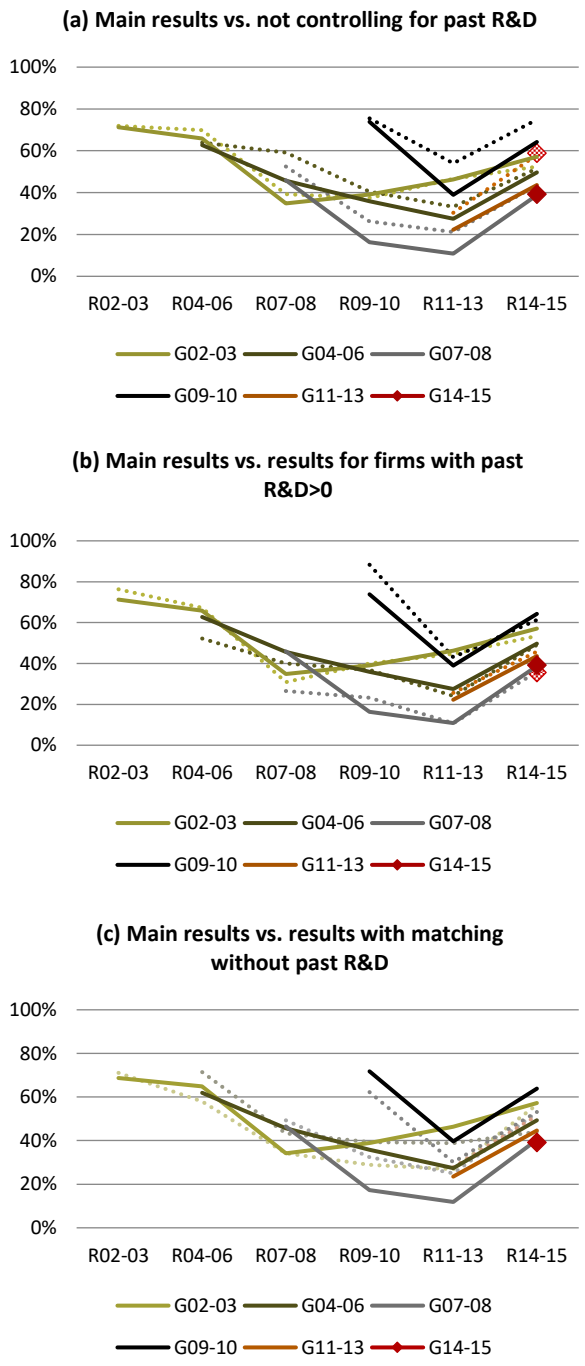
Because the dependent variable is in natural logs, the percentage effects can be calculated as *exp(α)-1*. These effects are demonstrated in Figure 4.10 where the calculated effects from the main model specification (cf. column 5 in Table 4.12) are compared with other model specifications, i.e. with results from column 4 in panel (a), from column 6 in panel (b) and from column 2 in panel (c).

Table 4.12 Diff-in-diff estimation results by policy regime and user generation (only SkatteFUNN effects)

Coefficients		Matching without R&D experience			Matching with R&D experience		
Generation	Regime	(1) Without control for past R&D	(2) With control for past R&D	(3) Past R&D>0	(4) Without control for past R&D	(5) With control for past R&D	(6) Past R&D>0
G02-03	R02-03	0.514***	0.546***	0.545***	0.536***	0.538***	0.567***
G02-03	R04-06	0.480***	0.452***	0.454***	0.530***	0.506***	0.514***
G02-03	R07-08	0.312***	0.300***	0.286***	0.331***	0.299***	0.269***
G02-03	R09-10	0.228***	0.255***	0.256***	0.318***	0.330***	0.336***
G02-03	R11-13	0.237***	0.232***	0.240***	0.383***	0.380***	0.369***
G02-03	R14-15	0.417***	0.440***	0.420***	0.421***	0.452***	0.428***
G04-06	R04-06	0.563***	0.545***	0.503***	0.488***	0.487***	0.420***
G04-06	R07-08	0.431***	0.359***	0.346***	0.465***	0.376***	0.336***
G04-06	R09-10	0.366***	0.337***	0.340***	0.340***	0.307***	0.314***
G04-06	R11-13	0.383***	0.328***	0.317***	0.287**	0.243**	0.216*
G04-06	R14-15	0.378***	0.365***	0.345***	0.415***	0.403***	0.399***
G07-08	R07-08	0.434***	0.404***	0.320***	0.422***	0.378***	0.235**
G07-08	R09-10	0.356***	0.278***	0.313***	0.233**	0.151	0.209*
G07-08	R11-13	0.319***	0.219**	0.233***	0.192	0.103	0.102
G07-08	R14-15	0.467***	0.418***	0.419***	0.362**	0.328**	0.307**
G09-10	R09-10	0.482***	0.488***	0.536***	0.551***	0.553***	0.633***
G09-10	R11-13	0.358***	0.252***	0.297***	0.432***	0.329***	0.358***
G09-10	R14-15	0.497***	0.421***	0.412***	0.559***	0.496***	0.478***
G11-13	R11-13	0.305***	0.238***	0.274***	0.265***	0.201***	0.228***
G11-13	R14-15	0.523***	0.411***	0.443***	0.458***	0.362***	0.377***
G14-15	R14-15	0.451***	0.337***	0.383***	0.461***	0.329***	0.304***
No. of obs.		27050	25213	21170	14610	13992	11121
No. of firms		5990	5720	4935	3489	3402	2841

Notes: One, two, and three stars indicate significance at 1, 5, and 10 per cent levels, respectively.

Figure 4.10 SkatteFUNN effects by user generation and policy regime



Source: Samfunnsøkonomisk analyse AS

As we can observe from Figure 4.10, the impact of SkatteFUNN varies a lot dependent on the generation and policy regime. The highest effect is observed for the first generation and those started to use SkatteFUNN in 2009 (after the first increase of the project cost cap). The lowest impact is observed for the generation that started to use SkatteFUNN after implementation of the hourly wage cap in 2007. The effect is not significantly different from zero under the regimes 2009-2010 and 2011-2013.

For all generations input additionality is strongest just after they started to use SkatteFUNN and is declining with time. However, the recent increases in the project cost cap in 2014-2015 seems to stimulate all generations to invest more in R&D.

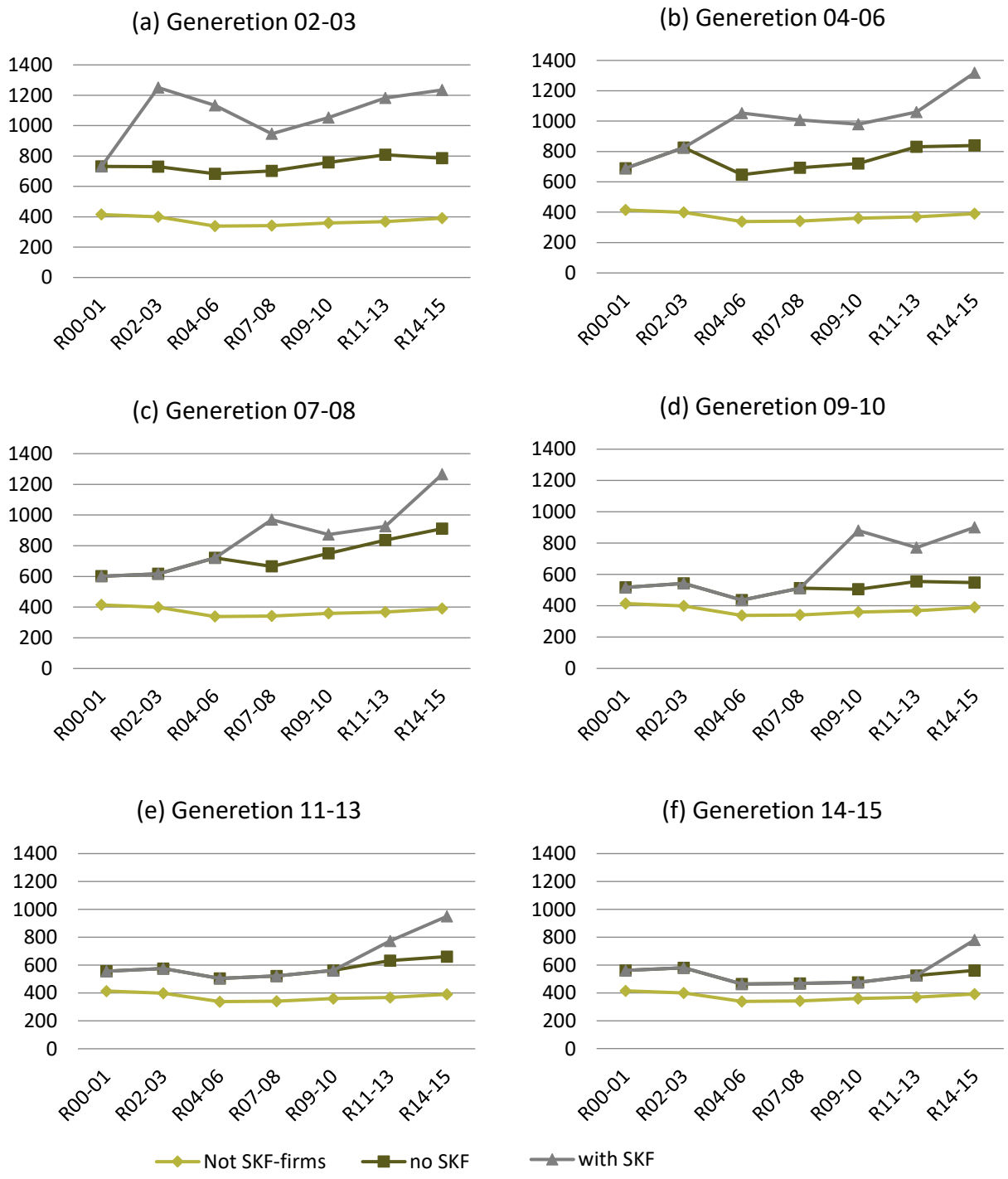
When we compare different model specifications, we see that not controlling for past R&D experience results in an overestimated impact of SkatteFUNN (cf. dot lines in the panel (a) of Figure 4.10).

While comparing our main results with those for firms with strictly positive R&D in the previous three-year period (i.e. R&D-performers), we get a mixed picture. The impact for R&D-performers is lower for the 2004-2006 and 2007-2008 generations, slightly higher for the 2002-2003 and 2009-2010 generations and similar for the 2011-2013 and 2014-2015 generations (cf. dotted lines in the panel (b) of Figure 4.10). An explanation could be that R&D-performers were more stimulated by increases in the cap, and more harmed by introduction of the hourly wages cap, than firms without R&D experience.

The results are less heterogeneous after matching without controlling for past R&D experience (cf. the dotted lines in panel (c) of Figure 4.10).

To get a better insight into impact of SkatteFUNN, we summarize the most important results in Figure 4.11.

Figure 4.11 R&D expenditures for different SkatteFUNN-user generations by policy regime against the benchmark of no use



Source: Samfunnsøkonomisk analyse AS and Statistics Norway

Each panel in Figure 4.11 shows the predicted R&D expenditures for the different generations of beneficiaries and non-beneficiaries, over time in the hypothetical case without SkatteFUNN (the counter-factual development).[74] The upper lines at each panel demonstrate the development of R&D expenditures, including the impact of SkatteFUNN (corresponding to the given generation-policy regime combination). The difference between the upper line and the benchmark is additional R&D expenditures caused by SkatteFUNN for the given generation.

Note that the group of non-beneficiaries has the lowest R&D expenditure over the entire period. Thus, simply comparing non-beneficiaries and beneficiaries when estimating the policy's impact will give a strongly overestimated result. Such differences are also observed between the different generations of beneficiaries. The first two generations (G02-03 and G04-06) have the highest initial R&D investment, while last three generations (G09-10, G11-13 and G14-15) exert a remarkably lower initial R&D investment than the previous generations of beneficiaries. Thus, we observe the same clear pattern as by Mohnen et al. (2017), i.e. the higher the R&D investment, the earlier the firms make use of the R&D policy (innovation box in their case and SkatteFUNN in our case).

4.4.6 Bang for the buck

We also want to know how much the (bang for the buck) BFTB measure vary across user generations and policy regimes. This measure shows how much additional R&D has been induced per krone spent on the scheme.[75]

To calculate the BFTB, we need to sum up all additional R&D expenditures caused by SkatteFUNN (the area between the upper line and the benchmark line in each panel of Figure 4.11). This is the generational 'bang' measure. The 'buck' is the SkatteFUNN tax deduction received by a given generation during the period of SkatteFUNN usage. Then the generational BFTB measure is obtained by dividing the generational 'bang' by the generational 'buck'.

We can also accumulate additional R&D expenditures and received tax credits for each generation-policy regime combination and get generation-policy regime specific BFTB measures. The total sum of additional R&D expenditures divided by the total sum of received tax credits across generations and regimes gives us the overall BFTB measure. All these calculated measures are presented in Table 4.13 based on the main model (after matching with the indicator for past R&D experience as an extra control variable) and in Table C4 based on the alternative model (after matching without controlling for past R&D experience).

Table 4.13 "Bang for the buck": main model (after matching, controlling for the past R&D experience)

Regime	All generations	G02-03	G04-06	G07-08	G09-10	G11-13	G14-15
R02-03	2.22	2.22					
R04-06	2.68	2.86	2.41				
R07-08	2.34	2.26	2.83	1.63			
R09-10	1.95	2.21	2.38	0.74	2.15		
R11-13	1.60	3.07	1.85	0.65	1.64	0.90	
R14-15	1.66	2.34	2.47	1.42	2.17	1.45	1.15
Total	2.07	2.55	2.42	1.06	1.91	1.12	1.15
For firms with past R&D>0	2.04	2.47	2.33	0.94	1.99	1.29	1.17

Our main model gives us an overall BFTB of 2.07 (2.04 for R&D performers). The alternative model gives slightly higher results (2.16 for all firms with past R&D information and 2.17 for R&D doers correspondingly). The generation-regime specific BFTB values in Table 4.13 range from 0.65 to 3.07, showing high variation of the effects. However, most

[74] The case when all α in (2) are set to zero. i.e. we extract from the predicted values the corresponding to the generation-policy regime α value.

[75] Both R&D expenditures and tax credit amounts are deflated by R&D personal cost index.

effects are much higher than 1, confirming the high input additionality of SkatteFUNN.

From both tables we can see that SkatteFUNN was most effective for the two first generations of SkatteFUNN beneficiaries. These two generations were also most stimulated by the recent changes in the scheme, i.e. the project cost cap increases in 2014-2015. Generation 2007-2008 performs most poorly, followed by recent generations of SkatteFUNN beneficiaries. Note also that generation 2007-2008 of R&D performers (those with past R&D>0) have very low values of BFTB under regime 2009-2010 (0.74, and 0.90 for the whole period of evaluation). These numbers are not far from BFTB measure calculated in the previous chapter, possibly explaining that combining these specific beneficiaries with the period after a finical crisis gives us such low estimates.

The obtained results confirm strong selection of the firms into the scheme, i.e. firms with managers searching for opportunities and with high potential have made use of SkatteFUNN early. Conversely, the firms recently starting to use SkatteFUNN have delivered lower additionality.

As for variation in impact over regimes, we can observe that effects were strongest in the first two periods after SkatteFUNN introduction and slightly declining after. However, the recent increases in the project cost cap in 2014 and 2015 has again stimulated firms to invest more in R&D. The question of how long this positive response will last remains for later evaluations.

We also report variation in impact based on firm size under different policy regimes and for different generations. Table 4.15 shows that the additionality is higher for SMEs, than for large firms just after introduction of the scheme, but at the same range in the post-introduction periods and even somewhat higher for the large firms at the end of the analysed period. This observation raises a question on the rationale for differentiation of tax credit rates between SMEs and large firms, at least to how this definition is operationalized.[76] This is also discussed in chapter 10.5.

Table 4.14 "Bang for the buck" by size of firm

	SMEs	Large firms
Policy regime		
2002-2003	2.104	1.865
2004-2006	2.560	2.603
2007-2008	2.205	2.344
2009-2010	1.869	1.849
2011-2013	1.401	1.899
2014-2015	1.554	1.710
Generation		
2002-2003	2.442	2.214
2004-2006	2.284	2.696
2007-2008	1.105	1.064
2009-2010	1.786	2.914
2011-2013	1.125	0.992
2014-2015	1.103	1.292

Furthermore, we report variation of the SkatteFUNN effects for firms with positive lagged R&D versus firms reporting zero lagged R&D. Table 4.16 shows as expected that firms with zero R&D in period *t-1* exhibit higher additionality than firms with continuous R&D. One exception is the period just after the introduction of SkatteFUNN, with a possible explanation that firms already planning or performing R&D projects applied for the scheme a short time after its introduction at the end of 2002.

[76] Many firms that are SMEs according to the definition applied by Eurostat and operationalized by SkatteFUNN are relatively large in the context of Norwegian economy.

Table 4.15 "Bang for the buck" by R&D expenditure before SkatteFUNN

	$R\&D_{t-1}>0$	$R\&D_{t-1}=0$
Policy regime		
2002-2003	1.954	1.878
2004-2006	2.238	3.845
2007-2008	1.748	4.843
2009-2010	1.472	3.321
2011-2013	1.223	2.769
2014-2015	1.285	2.654
Generation		
2002-2003	1.970	4.384
2004-2006	1.987	3.674
2007-2008	0.900	1.894
2009-2010	1.480	3.449
2011-2013	1.012	1.365
2014-2015	1.106	1.008

Finally, we investigate the impact variation by size of received tax credit. In the evaluation of various R&D and innovation supporting schemes in Norway, Cappelen et al. (2016) find SkatteFUNN to be the most effective R&D scheme with respect to value added per million NOK in project support.[77] Furthermore, they find that the effect of SkatteFUNN is increasing with the amount of support, i.e. the effect is lowest if support is lower than NOK 0.5 million and is highest if support is higher than NOK 1.5 million during the three-year period.

Furthermore, we find that firms with small projects exhibit much higher input additionality than firms with large projects.[78] We discuss these findings more in chapter 10.5.

Table 4.16 "Bang for the buck" by size of project

	Tax credit amount in NOK million*			
	<0.1	0.1-0.25	0.25-0.5	>=0.5
Policy regime				
2002-2003	4.74	3.00	1.39	0.92
2004-2006	4.63	2.84	1.25	0.82
2007-2008	4.18	2.31	0.95	0.60
2009-2010	4.07	2.41	0.98	0.51
2011-2013	3.57	1.67	0.80	0.44
2014-2015	4.51	2.71	1.15	0.57
Generation				
2002-2003	4.67	2.93	1.26	0.78
2004-2006	4.52	2.63	1.14	0.69
2007-2008	3.66	1.90	0.76	0.38
2009-2010	4.48	2.57	1.22	0.56
2011-2013	3.50	1.70	0.79	0.43
2014-2015	4.20	2.15	0.90	0.41

* Based on the average project length of two years, the reported intervals for the annual tax credit correspond to the project total costs being < 1 million, 1-2.5 million, 2.5-5 million and >=5 million

[77] In this evaluation, the projects length is standardized to three years and the overall projects support includes the sum of support to the firm from all funding sources over the three-year project period. Then the project is defined to be a SkatteFUNN project if SkatteFUNN is the main of source of funding during the three-year project period. That is the case for the 91 per cent of the projects getting SkatteFUNN credit. More details on this specific analysis can be found in Nilsen et al. (2018).

[78] That is not a surprising result given that most of new beneficiaries of the scheme apply with small projects and do not have any R&D activity prior to application, cf. chapter 2.3.

5 Output additionality of SkatteFUNN

We have assessed SkatteFUNN's impact on innovation, productivity and external effects, i.e. the scheme's output additionality. We find that SkatteFUNN contributes to more product and process innovation, as well as patenting. We find that R&D investment enhance labour productivity in firms. Moreover, our results indicate that the effect on labour productivity is the same for RCN and SkatteFUNN projects, as for other R&D projects.

The external effects of R&D are difficult to measure quantitively. We apply a "distance to R&D" approach to identify such spillovers, though the results of this econometric analysis are inconclusive. In our survey SkatteFUNN beneficiaries report that projects have benefited the firms' customers in terms of better products. Moreover, most respondents answered that strengthened competitiveness and dissemination of competence through staff mobility and collaboration were results of the SkatteFUNN project(s).

In chapter 4, we found that SkatteFUNN stimulates firms' R&D investment (input additionality). Successful R&D projects are expected to lead to innovations, which in turn increase production and profitability. The effect of SkatteFUNN on innovation, production and profitability is called output additionality. In this chapter, we analyse the effects of SkatteFUNN on the following performance indicators:

- Innovations, patents and other types of innovation protection
- Labour productivity
- External effects of SkatteFUNN (e.g. spreading of results or competence, improved products and increased competition)

R&D is an important factor behind innovations, and together with other intangible assets, such as data, patents, new organisational processes and firm-specific skills, it makes up a firm's *knowledge-based capital* (KBC). A lack of intangible assets and underinvestment in KBC are the main candidates for explaining the poor productivity performance of European countries relative to the USA (OECD, 2013).[79] The need for Europe to move into the *knowledge-based economy* and support investment in KBC has been an important focus of government policy in European countries, with R&D supporting programs being one of the main tools (OECD, 2013).

Cappelen et al. (2008) found that SkatteFUNN induced firms to implement new production processes and create products that were new to the firm. However, it was concluded that SkatteFUNN did not result in innovation of new patents or products that were new to the market. Hence, the scheme seemed to support incremental, rather than more radical innovation.

Cappelen et al. (2016) evaluated several R&D and innovation supporting schemes, including SkatteFUNN, and concluded that SkatteFUNN was more effective than direct subsidies in stimulating firms to patenting. This was measured by the number of triggered patents per krone public spending. However, direct subsidies were more effective than SkatteFUNN in stimulating of development of some specific types of technologies (e.g. green technologies).

Recently, a comparative analysis of tax credit schemes in Norway, France and Italy (cf. Freitas et al., 2017), using CIS data for 2004, 2006 and 2008 for manufacturing firms, reported a positive and significant effect of SkatteFUNN on innovation output

[79] See, for instance, van Ark *et al.* (2003), O'Sullivan (2006), Moncada-Paternò-Castello *et al.* (2009), Hall and Mairesse (2009) and Hall *et al.* (2013).

(measured as a share of turnover from new or improved products).

Applying different models, we find that SkatteFUNN does induce firms to implement new production processes and products (both new to the firm and to the market). We also find that SkatteFUNN has a positive effect on the probability to patent, while other types of innovation protection remain unaffected.

As for SkatteFUNN's impact on productivity, Cappelen et al. (2008) found a positive impact on both productivity and productivity growth. The effect of SkatteFUNN was equivalent to that of other R&D activities. However, the results were too unclear to estimate the external effect of R&D in general, or SkatteFUNN projects particularly.

Cappelen et al. (2016) reports a positive effect of R&D capital on firm's labour productivity. This analysis looked specifically at support from SkatteFUNN and the Research Council of Norway (RCN), and found that firms receiving support from RCN or SkatteFUNN had lower return on R&D capital than those with no public support.

We apply a similar approach as in the two abovementioned evaluations and find that R&D investment in general, and over time, benefits the labour productivity in firms. Both RCN and SkatteFUNN projects have the same effect on labour productivity as other R&D projects.

The external effects of R&D are difficult to measure quantitively and the results of our econometric analysis are inconclusive. However, our survey among SkatteFUNN beneficiaries reports that projects have benefited the firms' customers in terms of better products. Moreover, most respondents stated that strengthened competitiveness and dissemination of competence through staff mobility and collaboration were results of the SkatteFUNN project(s).

5.1 Impact on innovation

Innovation in the private sector is regarded as an important driver of productivity growth, both at the firm and the national level. At the micro level, innovation has the potential to increase demand through improved product and service quality and decreased production costs. At the macro level, strong business innovation increases total factor productivity, thus increasing international competitiveness and economic growth.[80] It is therefore of great interest to firms and policy-makers to identify the factors that stimulate innovation.

We know that firms receiving support through SkatteFUNN are more likely to increase their R&D investments than other firms, cf. chapter 4. The main question in this chapter is whether these additional R&D efforts result in more innovative output.

5.1.1 Introduction of the model and estimation strategy

Let us consider a model of how innovation occurs. The modelling framework is influenced by Griliches (1990), Crepon *et al.* (1998) and Parisi *et al.* (2006). The main idea in this literature is that, by investing in R&D, the firm accumulates a knowledge capital stock, which plays an important role in its innovation activities. This idea can be presented by the following equation:

$$INNO_{it}^{*} = \delta_0 + \delta_1 \cdot r_{it} + X_{it}^{inno}\beta + \eta_{it} \qquad (5.1)$$

Let $INNO_{it}^{*}$ be a latent variable that measures the extent of R&D activity within the firm. The higher the value of $INNO_{it}^{*}$, the higher is the probability that an

[80] See, for instance, Crépon *et al.* (1998), Griffith *et al.* (2006) and Parisi *et al.* (2006) for the studies at the micro level, and van Leeuwen and Klomp (2006) for the study at the macro level.

innovation will occur. r is the R&D intensity measure, X_{it}^{inno} is a vector of different firm characteristics important for innovation output (e.g. firm size, industry, collaboration in R&D projects etc.), δ_1 and β are parameters (vectors) of interest, and η_{it} is an error term.

The previous empirical studies based on this type of model use different innovation output measures to proxy unobserved knowledge, $INNO_{it}^{*}$, e.g. the share of innovative sales (applied, for example, in Crepon *et al.*, 1998, Castellacci, 2011; and Freitas *et al.*, 2017); different binary innovation indicators (applied, for example, in Griffith *et al.*, 2006, and in Cappelen *et al.*, 2012, for product and process innovation; and in Polder *et al.*, 2009, for product, process and organisational innovation); and patent applications counts (applied, for example, in Crepon *et al.*, 1998, and Cappelen *et al.*, 2016, chapter 8).

Here, we analyse three types of innovations: a new (or improved) product for the firm, a new (or improved) product for the market, and a new (or improved) production process. We also use information on several types of innovation protection including patent applications, trademarks, design and copyright. In addition to these categorical measures that identify whether a firm innovates or not and whether it uses any innovation protection or not, we use information on the share of innovative sales (i.e. firm's turnover from new or improved products). We use all these innovation measures to identify which parts of innovation process are most affected by SkatteFUNN.

Since the CIS surveys cover a three-year period each and are partly overlapping, we cannot provide the same detailed analysis for different SkatteFUNN regimes with respect to changes of the scheme as we did in chapter 4. However, the timing of available (to us) CIS data, with CIS2001 covering the three-year period just before the implementation of SkatteFUNN and all other CIS versions (CIS2004, 2006, 2008, 2010, 2012 and 2014) covering periods after implementation, allows us to apply a simple diff-in-diff framework to the innovation analysis:

$$INNO_{it}^{*} = b_0 + b_1 D^1 + b_2 S_i + b_3 D^1 S_i + \delta_1 \cdot r_{it} + X_{it}^{inno}\beta + \eta_{it} \qquad (5.2)$$

D^1 is a dummy-variable equal to 1 for the period after treatment (when the policy is implemented or after a change) and 0 for the period before treatment (when the policy does not exist or before a change). S is an indicator for policy beneficiaries (a dummy variable that equal 1 if the firm has used SkatteFUNN in any year after introduction of the policy) and 0 for the control group of firms that have not used the policy.

Table 5.1 Overview of key variables in innovation analysis

Variable	Definition
Dependent variables:	
inpdt	1 if firm has introduced a new product for the firm in the given subperiod, 0 else
inmar	1 if firm has introduced a new product for the market in the given subperiod, 0 else
inpcs	1 if firm has introduced a new production process in the given subperiod, 0 else
turn_inno	Share of turnover from new or improved products (0-100 scale transformed to per centiles 1, 2, …, 10 in addition to 0).
patent	1 if firm has applied for a patent in the given subperiod, 0 else
trademark	1 if firm has applied for a trademark protection in the given subperiod, 0 else
design	1 if firm has applied for a design protection in the given subperiod, 0 else
copyright	1 if firm has applied for a copyright protection in the given subperiod, 0 else
Control variables:	
r	R&D intensity: R&D expenditures as a percentage of total turnover, average over the given subperiod
Δr	Additional R&D intensity generated by a tax credit, which is the treatment effect on the treated (TET) for each firm predicted from the input additionality analysis, average over the given subperiod
r^C	Counterfactual R&D intensity that each firm would have done in the absence of a tax credit (obtained as the difference between *r* and *Δr* for each firm in the sample
h	Share of man-hours worked by employees with high education (14 or more years of education), average over the given subperiod
coopg	1 if firm collaborated with a firm in the group in R&D in the given subperiod, 0 else
coopf	1 if firm collaborated with another firm in R&D in the given subperiod, 0 else
coopu	1 if firm collaborated with a university or research institute in R&D in the given subperiod, 0 else
SKF_firm	1 if firm uses SkatteFUNN at least once during the whole observational period, 0 else
d_SKF	1 if SkatteFUNN tax credit *> 0* in at least one year in the given subperiod, 0 else

The estimated parameter $\boldsymbol{b}_0$ then measures the average innovation effort for the control group in period 0. $\boldsymbol{b}_0+\boldsymbol{b}_1$ is the average innovation effort for the control group in period 1. $\boldsymbol{b}_2$ is the difference between the control group and the policy beneficiaries in period 0 (the difference before the policy is implemented, or changed, hence not part of the effect of the policy). $\boldsymbol{b}_0+\boldsymbol{b}_2$ is the average outcome for beneficiaries in period 0, while $\boldsymbol{b}_0+\boldsymbol{b}_1+\boldsymbol{b}_2+\boldsymbol{b}_3$ is the average outcome for these firms in period 1. Hence, $\boldsymbol{b}_3$, which is the difference-in-differences, measures the 'additionality' of SkatteFUNN in terms of additional innovation effort because of SkatteFUNN.

As mentioned earlier, given that assignment to SkatteFUNN is not random, a direct comparison of beneficiaries and non-beneficiaries will give a biased result. Firms who decide to use the scheme will likely make their decision because of certain factors that are not shared with firms that do not use the scheme. Some of these factors are observed and accounted for, and some are not. Then, an observed increase in innovation efforts for the beneficiaries of SkatteFUNN may be the result of these specific factors, rather than of the policy itself.

To consider this selection problem we use the dataset of SkatteFUNN-firms and control-firms that has been constructed by propensity score matching in chapter 4. This procedure allowed for constructing a control group of firms that are as comparable

to SkatteFUNN beneficiaries as possible, given observable characteristics prior to SkatteFUNN.[81] However, this dataset is now restricted to the firms that are represented in CIS data and, hence, does not include the smallest firms (with less than 5 employees) and many medium-sized firms (with 5-49 employees). At the same time the largest firms were excluded from the data sample after the matching procedure. As a result, we end up with 4577 observations where about half are SkatteFUNN-beneficiaries and half are non-beneficiaries with 60-70 employees as an average firm size (compared to 10 employees on average in the original matched dataset, cf. Table 4.11).

In the case of the binary innovation indicators (cf. table 5.1 for variables description), we observe innovation, $Y_{it}=1$, if latent innovation efforts $INNO_{it}^{*}$ have been higher than some level *c*, and we do not observe any innovation, $Y_{it}=0$, in the case of low innovation efforts:

$$Y_{it} = \begin{cases} 1 & if\ INNO_{it}^{*} > c \\ 0 & \text{elsewise} \end{cases}$$

In this case equation (2) is estimated on the pooled dataset as a *probit* model. In the case of innovative sales as an innovation indicator, equation (2) is estimated as an *ordered probit* model. We use an *ordered probit* model to account for the fact that the dependent variable in this equation (the firm's share of turnover from new or improved products) is defined as a categorical variable on an ordinal scale.[82]

We estimate two versions of equation (2). One version includes among the regressors the observed R&D intensity, *r*, and an indicator for participation in SkatteFUNN during a given three-year subperiod, *d_SKF*. We call it our reference model. Another version replaces these two regressors by two variables obtained by splitting the R&D intensity variable into two distinct terms. One is the additional R&D intensity generated by a tax credit (Δr), which is the treatment effect on the treated (TET) for each firm predicted from the main model for input additionality estimation in chapter 4.4. The other represents the R&D intensity that each firm would have had in the absence of a tax credit (r^C; where C stands for *counterfactual*); this is simply obtained as the difference between *r* and Δr for each firm in the sample.[83] This estimation method is inspired by Czarnitzki and Hussinger (2004), Cerulli and Poti (2012) and Freitas et al. (2017). We call it our main model.

Both models also include the set of time-dummies for each CIS wave after introduction of SkatteFUNN instead of only one dummy D^1 for the whole post-introduction period (three-year pre-SkatteFUNN period covered by CIS2001 is then the reference period). In this case, we do not distinguish among different generations of SkatteFUNN beneficiaries as we did in chapter 4.4, but apply a general indicator for SkatteFUNN-beneficiaries, *SKF_firm.*

In addition to the main variables described in table 5.1, we use the following firm characteristics in the analysis:

- *Firm size:* number of employees (log, log^2)
- *Sales intensity:* turnover per employee (log)
- *Liquidity constraint rate:* current assets/short-term debt (log), average over the given subperiod
- *Firm age*: number of years after establishment
- *Employees' age*: average age of employees in the given firm

[81] See chapter 4.4.4 for more details on the procedure and the description of the dataset

[82] In the surveys, the values for this variable are self-reported by the respondents and vary between 0-100 (per cent). As a result, the variable tends to be distributed unevenly and concentrated instead around a limited number of discrete values (e.g. 0, 10, 20, 30, …, 100). For this reason, we have transformed this variable into a categorical indicator taking integer values from 0 to 10 (as done in Czarntizki et al., 2011).

[83] For firms that do not receive a tax credit, the term Δr takes a value of 0, while the term r^C takes the same value as the firm's R&D intensity *r*.

- *Share of high-skilled employees:* Share of man-hours worked by employees with upper secondary education.
- *Market location*: a set of dummy variables indicating whether a firm sells its *main* products in local/regional, national, European or other international markets. This variable indicates the location of a firm's main competitors. The former category (local/regional market location) is the reference category.
- *Received subsidy*: a dummy variable indicating whether a firm has received a subsidy for carrying out R&D during the three years of the survey.[84]
- *Firm industry*: a set of dummy variables indicating the firm industry (see chapter 2.4.3 for the description of industries in our analysis). Bioeconomic is the reference industry.
- *Firm location*: a set of dummy variables indicating the region where the firm is located, i.e. North, South, West, East, central Norway, and the capital region (Oslo and Akershus). The latter category is the reference category.

To assess the robustness of the results, we have also carried out the estimation procedure for two different econometric specifications of each model version. The first is the baseline specification noted above and run on the whole sample of observations. The second specification includes the lagged value of the dependent variable. This specification allows for considering the persistent nature of innovation (cf. Petters, 2009). The drawback of this strategy, however, is that we lose a sizeable number of observations (due to the unbalanced nature of our panels).

5.1.2 Estimation results for innovation types

Table 5.2 reports the results of the estimation of our reference model for different innovation output proxies (a new or improved product for the firm, a new or improved production process, a new or improved product for the market, and the share of innovative sales). While Table 5.3 reports corresponding marginal effects for some key variables on the probability of innovation.

We can see that, irrespective of innovation output indicator and of the model specification (with or without controlling for innovation persistency)[85], the propensity to innovate has a similar relationship to the main explanatory variables, increasing strongly with R&D intensity and firm's sales intensity. For example, an increase of R&D intensity by one per cent increases the probability of a new product for the firm by 5.7 percentage points on average and the probability of a new product for the market by 4.5 percentage points (cf. columns 2 in Table 5.3).

Note that all types of innovation have a highly significant coefficient estimate of the lagged dependent variable, Y_{t-1}, implying that innovation is a rather persistent characteristic of a firm.

[84] Note that we also control for the use of other sources of public R&D support when we do matching of SkatteFUNN-beneficiaries with non-beneficiaries.

[85] Results in columns (1) yield specification that does not include the lagged dependent variable, while results in columns (2) yield specification that consider innovation persistency.

Table 5.2 Estimation results - Different innovation types. Reference model

Innovation type:	New or improved product		New or improved process		New product for the marked		Share of turnover from new products	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
R&D intensity (log)	0.273***	0.232***	0.180***	0.160***	0.253***	0.207***	0.269***	0.252***
Number of employees (log)	-0.09	-0.155	-0.238**	0.019	-0.063	-0.042	-0.014	-0.187
Number of employees (log^2)	0.015	0.026	0.041***	0.014	0.015	0.016	0.002	0.022
Turnover per employee (log)	0.056***	0.060**	0.066***	0.092***	0.033	0.038	0.040*	0.060**
Financial liquidity rate (log)	0.024	-0.046	0.008	0.023	0.018	-0.017	-0.008	-0.034
Organisational age	0.004**	0.002	0.001	-0.001	0.000	0.002	0.003	0.002
Mean age of employees	0.001	0	0.000	0.003	-0.005	-0.001	-0.008	-0.01
Share of high-skilled	0.459***	0.451**	-0.180	-0.296	0.329**	0.505**	0.260*	-0.078
Main marked: Norway	0.154***	0.113	0.099*	0.039	0.164***	0.127	0.138**	0.121
Main marked: Europe	0.09	0.134	-0.093	-0.081	-0.016	-0.112	0.035	0.133
Main marked: World	0.162*	-0.033	0.018	-0.11	0.155	-0.053	0.196**	0.193
Collaboration: in the group	0.225*	0.251*	0.090	0.094	0.145	0.146	0.023	-0.037
Collaboration: another firm	0.730***	0.653***	0.576***	0.503***	0.557***	0.386***	0.397***	0.284***
Collaboration: university	-0.075	-0.121	0.209**	0.175	0.071	0.085	-0.003	-0.082
d_subsidy	0.198	0.279	-0.061	-0.081	0.279	0.352	0.054	0.129
SKF_firm	0.207***	0.123	0.150**	0.014	0.116	0.108	0.222***	0.163
d_SKF	0.185**	0.233**	0.148**	0.203**	0.243***	0.273**	-0.041	-0.019
Y_{t-1}	-	0.790***	-	0.537***		0.717***		0.569***
Number of observations	4405	2162	4391	2161	4393	2162	3938	1841
Pseudo R2	0.30	0.34	0.18	0.20	0.27	0.29	0.25	0.15

Notes: All regressions include a constant, industry, location, and time dummies. Reference group: Local/regional market location, subperiod 1999-2001, Bioeconomic industry, firms in the capital region (Oslo and Akershus). The standard errors are robust to heteroscedasticity and clustered at the firm level. Dependent variable: binary indicators for different types of innovation or the ordinal indicator for innovative sales. Estimated by maximum likelihood as a probit model (oprobit in latter case) in Stata. *** p<0.01, ** p<0.05, * p<0.1

Table 5.3 Marginal effects for key variables - Different innovation types. Reference model

Innovation type:	New or improved product		New or improved process		New product for the marked		Share of turnover from new products	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
R&D intensity (log)	0.070***	0.057***	0.047***	0.041***	0.054***	0.045***	0.070***	0.065***
Share of high-skilled	0.118***	0.110**	-0.047	-0.075	0.070**	0.111**	0.068*	-0.020
Collaboration: in the group	0.058*	0.062*	0.023	0.024	0.031	0.032	0.010	-0.010
Collaboration: another firm	0.188***	0.160***	0.149***	0.128***	0.118***	0.085***	0.103***	0.073***
Collaboration: university	-0.019	-0.029	0.054**	0.044	0.015	0.019	-0.001	-0.021
d_SKF	0.048**	0.057***	0.038**	0.052**	0.052***	0.060***	-0.011	-0.005
Y_{t-1}	-	0.193***	-	0.137***	-	0.158***	-	0.146***
Number of observations	4405	2162	4391	2161	4393	2162	3938	1841
Pseudo R2	0.30	0.34	0.18	0.20	0.27	0.29	0.25	0.15

Notes: All regressions include a constant, industry, location, and time dummies. Reference group: Local/regional market location, subperiod 1999-2001, Bioeconomic industry, firms in the capital region (Oslo and Akershus). The standard errors are robust to heteroscedasticity and clustered at the firm level. Dependent variable: binary indicators for different types of innovation or the ordinal indicator for innovative sales. Estimated by maximum likelihood as a probit model (oprobit in latter case) in Stata. *** p<0.01, ** p<0.05, * p<0.1

Collaboration with another firm has also positive impact on the propensity to innovate for all types of innovation, while collaboration in the group has a positive impact only on the product innovation that is new to the firm.

Another key factor for innovation is employees' skills. Measured by the share of high-skilled workers in the firm, this factor has a positive impact on product innovation, but seems to be unimportant for process innovation. This result is consistent with Møen and Rybalka (2011).

National and international market orientation seems to have a positive impact on the propensity to innovate as well. However, this result is not robust to the inclusion of the lagged dependent variable indicating a possible reverse causality (i.e. that innovation can lead to a higher level of market orientation).

Interestingly, neither firm size, collaboration with universities or use of direct subsidies have any impact on the propensity to innovate. The most probable reason for that can be our sample construction procedure, when the largest firms that are main user of direct subsidies and are main collaborator with universities have been excluded under matching.

Finally, we can observe that our indicator for participation in SkatteFUNN, *d_SKF*, has positive impact on the propensity to innovate for all three types of innovation. This result is robust to model specification. For example, for a representative firm the effect of a change in the value of *d_SKF* from 0 to 1 on the probability of a new product for the firm is 5.7 percentage points and on the probability of a new production process is 5.2 percentage points (cf. columns 2 in Table 5.3). However, we do not find any significant impact of SkatteFUNN on innovative sales.

Table 5.4 reports the results for our main model that estimates the effects SkatteFUNN on innovation by splitting the R&D intensity variable into two distinct terms.[86] One is the R&D intensity that each firm would have done in the absence of a tax credit, r^C. The other term is the additional R&D intensity generated by a tax credit, Δr, that is predicted from the model used in chapter 4.4.

Table 5.4 Marginal effects for key variables - Different innovation types. Main model

Innovation type:	New or improved product		New or improved process		New product for the marked		Share of turnover from new products	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Additional R&D intensity, Δr	0.030***	0.047***	0.023***	0.050***	0.029***	0.041***	0.012*	0.031***
Counterfactual R&D intensity, r^c	0.070***	0.053***	0.045***	0.033***	0.051***	0.045***	0.068***	0.064***
Share of high-skilled	0.094**	0.086	-0.078**	-0.083	0.076**	0.107**	0.046	-0.066
Collaboration: in the group	0.065**	0.065**	0.030	0.030	0.038*	0.036	0.01	-0.011
Collaboration: another firm	0.197***	0.167***	0.155***	0.133***	0.126***	0.091***	0.109***	0.070**
Collaboration: university	-0.009	-0.011	0.063**	0.053*	0.022	0.027	0.011	-0.002
Y_{t-1}	-	0.203***	-	0.148***	-	0.163***	-	0.156***
Number of observations	4401	2158	4391	2151	4377	2158	3934	1841
	0.29	0.34	0.18	0.20	0.26	0.29	0.14	0.15

Notes: All regressions include a constant, industry, location, and time dummies. Reference group: Local/regional market location, subperiod 1999-2001, Bioeconomic industry, firms in the capital region (Oslo and Akershus). The standard errors are robust to heteroscedasticity and clustered at the firm level. Dependent variable: binary indicators for different types of innovation or the ordinal indicator for innovative sales. Estimated by maximum likelihood as a probit model (oprobit in latter case) in Stata. *** p<0.01, ** p<0.05, * p<0.1

[86] We do not report here the corresponding table 5.2 results for the sake of space, but they are available upon request. These results are in general like those in table 5.2 and lead to the same conclusions.

Both, the counterfactual R&D variable, r^C, and additional R&D intensity, Δr, have positive and significant effects on innovation output irrespective of innovation indicator and of the model specification. This result is in line with analogous previous exercises carried out for product innovation by Czarnitzki at al. (2011) and Freitas et al. (2017).

If we compare marginal effect of additional R&D with the one of counterfactual R&D, the former is of the lower magnitude for the product innovation and of the higher magnitude for the process innovation (cf. columns 2 in

Table 5.4). This result is in line with Cappelen et al. (2012), where the strongest effect of SkatteFUNN was identified for the process innovation. However, in contrast to the results in the previous evaluation we also find a positive effect of SkatteFUNN for new products for the marked.

5.1.3 Estimation results for patents and other types of innovation protection

In this chapter we repeat the estimation procedure as of previous chapter, but here the different types of innovation protection is used as the dependent variables in model (2). The types of innovation protection included in our analysis are patent applications, trademark applications, design protection and copyright.

From table 5.5 we can see that larger and more mature firms tend to protect their innovation more often. As in the case with different innovation types, the propensity to apply for a patent or another type of innovation protection is increasing strongly with R&D intensity and firm's sales intensity.

Note that protecting innovation is also a rather persistent characteristic of a firm, i.e. the coefficient estimates of the lagged dependent variable, $Y_{t-1,}$ is highly significant for all types of protection. This yield patent applications, i.e. given that a firm has applied for a patent in the previous subperiod, the probability to apply again is 20 percentage points higher than for the firm without a patent application in the previous subperiod (cf. Table 5.6).

Firms that collaborate with other firms, are not only innovating more, but also protecting their innovation more often. Workers' skills, being important for product innovation, also have a highly positive effect on patenting.

The rest of the results have the same interpretation as for innovations except the SkatteFUNN indicators. While the *SKF_firm* variable (an indicator for the scheme's beneficiaries) has positive and significant coefficients in the models for innovation types (implying that SkatteFUNN-beneficiaries innovated more than non-beneficiaries even before the existence of SkatteFUNN), SkatteFUNN-beneficiaries do not differ in their behaviour from non-beneficiaries when it yields innovation protection prior to the introduction of SkatteFUNN.

Furthermore, an indicator for participation in SkatteFUNN, *d_SKF*, has positive impact only on the propensity to apply for a patent. This result is robust to model specification. For example, for a representative firm the effect of a change in the value of *d_SKF* from 0 to 1 on the probability of applying for a patent is 5.5 p.p. (cf. columns 2 in Table 5.6). We do not find any significant impact of SkatteFUNN on other types of innovation protection.

Table 5.7 reports the corresponding results for our main model that estimates the impact of SkatteFUNN on innovation by splitting the R&D intensity variable into counterfactual R&D intensity, r^C, and the additional R&D intensity generated by a tax credit, Δr.

Table 5.5 Estimation results - Different types of innovation protection. Reference model.

Innovation protection:	Patent		Trademark		Design		Copyright	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
R&D intensity (log)	0.123***	0.078**	0.136***	0.102***	0.116***	0.104**	0.082***	0.102***
Number of employees (log)	0.649***	0.554**	0.663***	0.746***	0.450***	0.451**	0.632***	0.639***
Number of employees (log^2)	-0.065**	-0.049*	- 0.070***	-0.079**	-0.033	-0.036	- 0.066***	-0.060**
Turnover per employee (log)	0.102***	0.076**	0.057**	0.056*	0.05	0.092**	0.037	0.052
Financial liquidity rate (log)	-0.066	-0.092	-0.024	-0.015	-0.007	0.005	-0.007	0.039
Organisational age	0.006***	0.002	0.006***	0.006**	0.003	0.003	0.000	-0.001
Mean age of employees	0.013	0.021**	-0.007	-0.001	0.014	0.022*	-0.001	0.01
Share of high-skilled	0.425**	0.527**	0.093	0.095	0.053	0.296	0.596***	0.816***
Main marked: Norway	0.179**	0.133	0.179***	0.160**	0.205**	0.145	0.169**	0.06
Main marked: Europe	0.154	0.084	0.230***	0.018	0.239**	0.132	0.202*	0.06
Main marked: World	0.363***	0.057	0.161	0.024	0.140	0.019	0.276**	0.045
Collaboration: in the group	0.139	-0.098	0.230**	-0.03	0.252*	-0.027	0.029	-0.15
Collaboration: another firm	0.208**	0.265*	0.091	0.361***	0.191	0.533***	0.131	0.193
Collaboration: university	0.165	0.061	0.190*	0.14	-0.044	-0.131	0.124	0.19
d_subsidy	0.150	0.059	0.186	0.315	-0.113	-0.143	0.188	0.219
SKF_firm	-0.035	-0.094	0.009	-0.102	-0.104	-0.227	0.042	-0.031
d_SKF	0.258***	0.365***	0.027	0.115	-0.022	0.082	-0.12	-0.124
Y_{t-1}	-	1.329***	-	0.832***	-	1.101***	-	0.958***
Number of observations	4390	2162	4402	2156	3995	1830	3995	1830
Pseudo R2	0.18	0.29	0.14	0.21	0.16	0.25	0.13	0.19

Notes: All regressions include a constant, industry, location, and time dummies. Reference group: Local/regional market location, subperiod 1999-2001, Bioeconomic industry, firms in the capital region (Oslo and Akershus). The standard errors are robust to heteroscedasticity and clustered at the firm level. Dependent variable: binary indicators for different types of innovation protection. Estimated by maximum likelihood as a probit model in Stata. *** p<0.01, ** p<0.05, * p<0.1

Table 5.6 Marginal effects for key variables - Different types of innovation protection. Reference model.

Innovation protection:	Patent		Trademark		Design		Copyright	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
R&D intensity (log)	0.019***	0.011**	0.028***	0.021***	0.014***	0.014**	0.012***	0.015***
Share of high-skilled	0.065**	0.055**	0.019	0.019	0.006	0.040	0.085***	0.124***
Collaboration: in the group	0.021	-0.015	0.047**	-0.006	0.031*	-0.003	0.004	-0.023
Collaboration: another firm	0.032**	0.040**	0.019	0.074***	0.024*	0.072***	0.019	0.029
Collaboration: university	0.025*	0.010	0.039*	0.029	-0.005	-0.017	0.018	0.028
d_SKF	0.039***	0.055***	0.006	0.023	-0.003	0.011	-0.017	-0.019
Y_{t-1}	-	0.200***	-	0.170***	-	0.150***	-	0.146***
Number of observations	4390	2162	4402	2156	3995	1830	3995	1830
Pseudo R2	0.18	0.29	0.14	0.21	0.16	0.25	0.13	0.19

Notes: All regressions include a constant, industry, location, and time dummies. Reference group: Local/regional market location, subperiod 1999-2001, Bioeconomic industry, firms in the capital region (Oslo and Akershus). The standard errors are robust to heteroscedasticity and clustered at the firm level. Dependent variable: binary indicators for different types of innovation protection. Estimated by maximum likelihood as a probit model in Stata. *** p<0.01, ** p<0.05, * p<0.1

Table 5.7 Marginal effects for key variables - Different types of innovation protection. Main model.

Innovation protection:	Patent		Trademark		Design		Copyright	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Additional R&D intensity, Δr	0.011**	0.022***	-0.003	0.003	0.002	0.010	-0.006	-0.011
Counterfactual R&D intensity, r^c	0.025***	0.018***	0.029***	0.024***	0.016***	0.016**	0.014***	0.018***
Share of high-skilled	0.092***	0.083*	0.021	0.001	0.005	0.050	0.079***	0.111**
Collaboration: in the group	0.027	-0.009	0.048**	-0.006	0.034**	0.001	0.001	-0.023
Collaboration: another firm	0.033**	0.045**	0.024	0.083***	0.027*	0.080***	0.022	0.037
Collaboration: university	0.022	0.004	0.040*	0.030	-0.009	-0.026	0.015	0.026
Y_{t-1}		0.197***		0.169***		0.152***		0.145***
Number of observations	4382	2158	4398	2158	3988	1807	3988	1821
	0.19	0.29	0.14	0.21	0.17	0.25	0.14	0.19

Notes: All regressions include a constant, industry, location, and time dummies. Reference group: Local/regional market location, subperiod 1999-2001, Bioeconomic industry, firms in the capital region (Oslo and Akershus). The standard errors are robust to heteroscedasticity and clustered at the firm level. Dependent variable: binary indicators for different types of innovation protection. Estimated by maximum likelihood as a probit model in Stata. *** p<0.01, ** p<0.05, * p<0.1

We observe the same pattern here. While the counterfactual R&D variable, r^C, has positive and significant effects on innovation protection, irrespective of protection indicator and model specification, the additional R&D intensity, Δr, has positive effect only on patents.

This positive result for patents is in line with Cappelen et al. (2016), who find that both direct subsidies and tax credit have positive effects on firms' probability to apply for more patents. While direct subsidies triggered a higher number of patents among firms between 2002 and 2011, SkatteFUNN was more effective given the number of triggered patents per krone spent.[87]

All in all, our analysis provides a clear and robust evidence on the existence of output additionality for SkatteFUNN, i.e. that participation in SkatteFUNN results in the creation of new products and processes, an increase in firms' turnover from new products and more patenting.

5.2 Impact on productivity

In the following, we will look at what effect R&D investment have on firm performance, more specifically, what effect SkatteFUNN has on productivity.

It is reasonable to assume that R&D investment carried out today yields a return tomorrow. Our analysis is therefore based on an economic model of firm behaviour where accumulated R&D investment, or R&D capital, is the relevant explanatory variable when we seek to estimate the effect of R&D on productivity. By assessing which mechanisms have been present and estimating parameters in an economic model that follow from assumptions, we can calculate the return on R&D capital.

The recent study by Møen (2018) estimates the private return on R&D financed by SkatteFUNN and finds a *gross return* of 16 per cent. The gross private return of R&D financed by own funds was estimated to be 19 per cent. Cappelen et al. (2016) estimate the *net return* of SkatteFUNN-projects and privately financed R&D to 9 per cent. The net return to R&D

[87] The first evaluation of SkatteFUNN, however, did not find any significant effect on patents (cf. Cappelen et al. 2008). One possible explanation is that their evaluation period was too short. They studied only the first three-year period after the introduction of SkatteFUNN, but it may take longer before such results as new patents appear.

financed by RCN was however estimated at only 7 per cent.[88]

Both our model and R&D capital specification follows Cappelen et al (2016). This means that for all practical purposes, our estimation is a reestimation using longer time series. The following outlines the theoretical background for our empirical analysis.

5.2.1 Calculating R&D capital

Statistics Norway's R&D statistics do not give any information about firms' R&D capital, but rather their annual R&D investment. We therefore construct a time series for R&D capital in each firm in our sample. For the firms who reported no R&D investment in any year of the R&D survey, the R&D capital is zero. For firms with positive R&D investment, we estimate R&D capital using the "perpetual inventory method" (PIM). Based on firms' gross R&D investment in every year (J_t), R&D capital (F_t) is estimated using the following equation:

$$(5.3)\quad F_t = J_t + F_{t-1} - D_t = J_t + (1-d)F_{t-1}.$$

D_t denotes the depreciation of initial capital stock during the year. All variables are deflated using a gross R&D investment price index. This is standard practice in National accounts. The first equation says an increase in capital (F_t-Ft_{-1}) equals investment minus depreciation (J_t-D_t). The next step involves a decision on depreciation.

Standard in the literature, is an assumption of depreciation equalling a fixed share of capital each year, thus making $D_t = d*F_{t-1}$. Inserting this in place of D_t in equation 5.3, leads to the expression on the right-hand side. By repeated insertion, F can be written as a weighted sum of investment over time and the initial capital stock (F_0).

Since F_0 cannot usually be observed, we estimate the initial capital stock assuming firms were in equilibrium in the initial year. That is, gross investment amounted to what was required to reproduce capital along an even growth path, characterized by a growth rate "g". This means $F_0 = J_1/(g+d)$. We set d = 0.15, which is standard in the literature (Hall, Mairesse, & Mohnen, 2010).[89] We estimate g by using the time series for firms in our sample.

Inserting the estimated value for the initial R&D capital stock for each firm, we use the equation 5.2 to calculate F_t for each firm. With this method, firms with no R&D investment one year, still has R&D capital if it made R&D investment in a previous year.

5.2.2 Theoretical model and econometric specification

In the following, we put forward a theoretical model to explain what mechanisms we allow for and how we suppose R&D capital affects value added. We then present our econometric specification.

Note that, since we are talking about R&D capital, R&D investment back in time can have a positive effect on firms' value-added years later. However, recent R&D investment count more than earlier ones, since investment depreciate over time.

Also note that, when analysing the effects of R&D capital in total, support from SkatteFUNN and RCN is treated symmetrically and in sum. This approach has empirical support in Cappelen et al (2013). RCN register their support with the contract partner, while R&D activity also occurs in the collaborating partners (firms). We avoid this problem in the data by

[88] Net return estimates take the depreciation of R&D capital into account and hence are lower than gross return estimates.

[89] Under certain conditions it can be shown that this means R&D investments has a life expectancy of about 13 years. 15 per cent depreciation is high, considering this means R&D investments are "reduced in value" already the year after the investment was made and few R&D investments are expected to give a return within one year. There are alternatives to this depreciation, and the choice influences the results. However, we choose this value since it is standard in the literature and allows a comparison to previous estimates, i.e. Cappelen et al. (2016).

utilizing the R&D statistics, which register actual R&D expenses, regardless of how the R&D is funded.

Many firms in Statistics Norway's R&D survey report no R&D investment in the annual R&D surveys. Thus, they have zero R&D capital. Several analyses of R&D return remove these firms from the sample used in estimation. This is potentially a drastic selection, since it involves an idea of "the effect of something can only be estimated among those doing this something". An analogy could be estimating the effect of smoking, but only including those who smoke in the sample. Like Cappelen et al (2016), we do not agree with such a strategy, a priori. The consequence of including firms with zero R&D capital is that our model must allow for positive production although R&D capital equals zero. This has implications for which functional form we can use.[90]

In Cappelen et al (2013), a similar issue is analysed using equivalent data. Assume there are two inputs in production; labour (L) and R&D capital (F). Together they produce gross value added (Y). The production function specified in Cappelen et al (2013) can, in a simplified version, be written as

$$(5.4)\ Y = \gamma_0 L^a (bL + F)^{1-a}.$$

Here, γ_0 and b are constants and a is a parameter. Setting b = 0 would mean (5.4) corresponds to a simple Cobb-Douglas function. As can be seen, F = 0, allows Y>0, meaning this functional form allows for zero R&D capital and positive production.

In this study, we will adopt a slightly different approach to that of Cappelen et al. (2013). We assume firms produce heterogenous products that face falling demand curves. More specifically, demand for a product falls when the firm increases its price, but if all prices increase just as much, in percent, and income follows the general price increase, demand for any firm's product does not change. Furthermore, we assume that firms use labour, goods, R&D capital and other real capital as inputs in their production. Firms can have zero R&D capital but must otherwise have positive real capital. We also assume R&D capital contributes to labour productivity.

With these assumptions, one can establish a relation between labour productivity, measured as value added per hour worked, the relationship between the price of goods and labour and factors affecting efficiency in the use of labour, including R&D capital. We allow for a separate effect on productivity from highly educated labour by including the share of highly educated labour in firms.

$$(5.5)\ ln(\frac{y}{L})_{i,t} = c_{0,i} + c_1 D_t + c_2 (F/L)_{i,t} + c_3 (H/L)_{i,t} + c_4 D_{i,j,t} + u_{i,t}$$

The model includes firm fixed effects, $c_{o,i}$, a variable D_t which captures common shocks in each year included in the analysis, the variable F/L which shows how much R&D capital per employee is present in each firm at the start of each year, the share of highly educated employees in each year, denoted by the expression H/L, and a set of dummy variables $D_{i,j,t}$ capturing each firm's industrial affiliation, region, age and whether the firm collaborated with others in regard to their R&D activity. The right-most variable in equation (5.5), $u_{i,t}$, is an error term allowed to depend on itself in previous periods (auto correlated residuals that follow an AR(1) process), which is a way of capturing sluggishness in changes in firms' adaptation.

[90] The following requires some knowledge of mathematical analysis. The reader can skip to the text starting after equation (5.4) to avoid technical details.

If we put y = ln(Y/L), f = F/L and h = H/L, a dynamic version of (5.5) that allows for autocorrelated residuals would look like:

$$(5.6)\ y_{i,t} = ay_{i,t-1} + b_{0,i} + b_1 D_t + c_2 f_{i,t} + b_2 f_{i,t-1} + c_3 h_{i,t} + b_3 h_{i,t-1} + \sum j\, b_{4j} D_{i,j,t} + e_{i,t}$$ [91]

We want to test the null hypothesis; projects subsidised by RCN and SkatteFUNN has the same productivity effect as other R&D projects, against the alternative hypothesis; projects subsidized by RCN and SkatteFUNN has a lower productivity effect than other R&D projects.

To test the null hypothesis, we include dummy variables for RCN support and SkatteFUNN separately, which interact with firms' R&D capital and takes the value 1 if the firm has received support from RCN or SkatteFUNN and 0 if the firm has not.[92]

We expect the effect of the dummy variable interactions to be negative. That is, we expect that RCN and SkatteFUNN support contributes to lowering the marginal return to R&D. This is because projects with public support are, by definition, not fully financed by the firms, and hence have a lower expected payoff for the firms, otherwise they would have done the projects without applying for RCN support or using SkatteFUNN. Moreover, a negative effect is in line with the previous evaluation of public R&D support (Cappelen et al., 2016).

The above specification and our estimation method means we must observe firms for at least three years in a row, for them to be included in the estimation of the parameters of equation (5.4). The results reported in table 5.9, are generated using an estimation method that both allows for autocorrelated residuals[93] and differences in equation (5.4) to eliminate the firm fixed effect $b_{o,i}$ (which also means variables dated year t, t-1 and t-2 are included).[94] Even after imposing this restriction of having to observe firms for at least three years, we are still left with unreasonable firm observations; for example negative value added. These firms are excluded

Table 5.8 Descriptive statistics on the number of firms in different categories of the estimation sample.

Year	No. of firms	No. of firms with SkatteFUNN	No. of firms with main support from SkatteFUNN	No. of firms with RCN support	No. of firms with main support from RCN	No. of firms with both RCN and SkatteFUNN funding	No. of firms with positive R&D investment, but no RCN or SkatteFUNN funding
2003	968	259	249	36	22	24	211
2004	1095	342	332	43	25	28	189
2005	1228	338	319	88	49	58	213
2006	1271	332	308	153	86	91	204
2007	1269	277	243	186	121	99	215
2008	1228	259	223	186	122	100	222
2009	1234	281	244	214	146	105	203
2010	1327	292	261	234	154	111	203
2011	1343	282	244	247	173	112	193
2012	1386	299	253	273	197	122	196
2013	1416	320	271	288	210	127	180
2014	1318	347	292	307	209	153	158
2015	1137	378	319	314	193	180	123

[91] Here, $b_{0,i} = (1-a)\, c_{o,i}$, $b_1 = (1-a)\, c_1$ $b_2 = -a\, c_2$, $b_3 = -a\, c_3$ and $b_4 = (1-a)\, c_4$, where a is the parameter of autocorrelation

[92] These interaction expressions are not included in (5.4) for the sake of simplicity.

[93] Previous results evidence the existence of autocorrelated residuals. See Cappelen et al (2016).

[94] GMM denotes "generalized method of moments". More specifically we have utilised an estimation method conceived by Arellano and Bond (1991), which is an instrumental variable method. Sargan tests are employed to verify the validity of our instruments.

from the analysis. We also exclude some observations where the relationship between R&D capital and productivity is unreasonably strong. In the data, we also observe some "new" firms with a high level of R&D investment as share of value added. These are most likely not new firms, but separated divisions of larger firms, and we therefore exclude some of the more R&D intensive firms in this group.

There are 2149 firms in our estimation sample. Table 5.8 show the number of firms in different categories of the estimation sample.

5.2.3 Results

The results are reported in table 5.9. In the column called "Model of reference", we report the results of the core model where we do not include dummies for who firms receive support. The column called "Main model" reports the model where dummies for RCN and SkatteFUNN support are included. This model is the most relevant in evaluation terms, since it tells us whether SkatteFUNN support increases (or decreases) the return to R&D capital.

Overall, the results show that R&D capital has a positive effect on productivity, but that neither support from SkatteFUNN nor RCN have an impact on productivity. SkatteFUNN and RCN supported projects lead to the same productivity, as projects without public funding. As Table 5.9 shows, the estimated coefficient for R&D capital interacted with a dummy for SkatteFUNN as main support is positive and significant at the 10 per cent level, though only barely so.

The results are sensitive to sample selection.[95] We put most weight on the estimated return to R&D capital in the reference model, since it is relatively more robust than the main model, as well as being in line with the results of Cappelen et al. (2016).

Using GMM estimation involves the use of instruments. We use Sargan tests[96] to validate our instruments. Whether this test accepts our instruments is also sensitive to sample selection. However, our instruments are valid for the data we use and in the models behind the reported results, as evidenced by the reported Sargan tests.

As mentioned above, we trust the results reported in the reference model column more than that of the main model. The estimated average marginal return to R&D capital is 8.2 per cent, in line with the results of Cappelen et. al (2016). This rate of return can be interpreted as a net return rate after a depreciation of R&D investment of 15 per cent is subtracted.[97] Note that this is an average effect of all R&D capital, including, and not differentiating between, R&D capital stemming from R&D investment that were supported by RCN and SkatteFUNN.

When considering the estimated R&D elasticities and marginal return to R&D in the main model, note that the estimates for those with SkatteFUNN and RCN support are not significantly different from those with no support.

Both models' results show that labour productivity increased with the share of highly educated employees. Furthermore, the effect of collaboration with research and educational institutions is positive and significant in the main model.

[95] In the results reported, we exclude the top and bottom 1per cent of predicted values from a quantile regression log productivity as the dependent variable with year and industry dummies. We also drop observations based on the top and bottom 1 per cent of R&D intensity and the top 5 per cent of newly established firms by R&D intensity.

[96] The Sargan test was first published in Sargan (1964). It is a test of the validity of the instruments used in regression. If the instruments are valid, they are uncorrelated with the residuals. If the test statistic is larger than the critical value, we reject the zero hypothesis that all instruments are valid and conclude that at least one if not exogeneous.

[97] In our measure of value added (Y), we use information from the R&D statistics to remove internal R&D costs (wages and goods). In addition, internal R&D personnel is removed from labour (L).

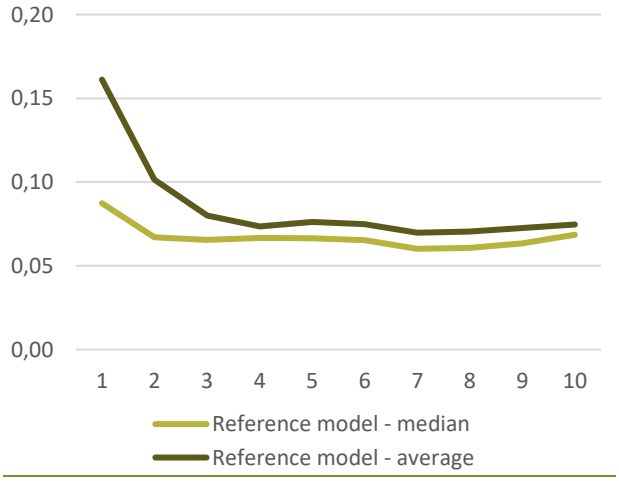
Table 5.9 Estimated productivity equations, 2003-2015. Dependent variable y = ln(Y/L).

	Main model		Model of reference	
Explanatory variables	Short term coefficients	Long term coefficients	Short term coefficients	Long term coefficients
y_{t-1}	0.36 (0.01)***		0.384 (0.023)***	
f_t	0.156 (0.006)***	0.052 (0.008)***	0.182 (0.015)***	0.178 (0.018)***
f_{t-1}	-0.122 (0.006)***		-0.073 (0.012)***	
d_nfr x f_t	0.024 (0.003)***	-0.007 (0.011)		
d_nfr x f_{t-1}	-0.028 (0.006)***			
d_skf x f_t	0.023 (0.01)**	0.037 (0.022)*		
d_skf x f_{t-1}	0.0 (0.01)			
h_t	0.292 (0.079)***	0.257 (0.103)**	0.217 (0.127)*	0.327 (0.18)*
h_{t-1}	-0.127 (0.064)**		-0.016 (0.103)	
Collaboration with R&ED[1]	0.032 (0.007)***		0.019 (0.012)	
Collaboration with other firms	0.003 (0.005)		0.011 (0.008)	
Estimated R&D elasticity	0.004 (no support)	0.008 (RCN support)	0.012 (SkatteFUNN support)	0.02
Estimated marginal return from R&D	0.023 (no support)	0.027 (RCN support)	0.039 (SkatteFUNN support)	0.082
Observations	11 304		11 304	
Number of firms	2 149		2 149	
Wald chi test	26 844.98		2 418.28	
Sargan test (prob > chi)	0.088		0.055	

[1] R&ED stands for research and educational institutions
Standard errors in parenthesis. * significant at 10per cent, ** significant at 5 per cent, *** significant at 1per cent
Dummy variables for firm age, region, industry and time dummies are included, but not reported
d_nfr = 1 if firm has RCN as main support in year t, d_skf = 1 if firm has SkatteFUNN as main support in year t

In Figure 5.1 we show the estimated marginal return to R&D capital in the reference model, by deciles of R&D intensity. The figure shows that for a level of R&D intensity above the fourth decile of the distribution, the rate of return is quite similar. Also, the rate of return is quite stable and evenly distributed among the firms, since the median and average are similar. For those firms at the 35-40 per cent bottom part of the distribution of R&D intensity, the rate of return to R&D capital is more uneven, with some relatively high rates of return making the average higher than the median. Still, the median is relatively stable for all ten deciles, and shows little variation in the rate of return, except at the bottom and upper deciles. This is in line with Cappelen et al (2016).

Figure 5.1 Estimated average and median marginal rates of return to R&D capital by deciles of R&D intensity.



Source: Samfunnsøkonomisk analyse AS

Our main results from the econometric analysis are:

- The estimated effect of R&D capital on labour productivity is positive and significant. The marginal return to R&D capital is calculated to be about 8 per cent
- Neither the effect of RCN nor SkatteFUNN projects are significantly different to that of other R&D projects.

The conclusions of both bullet points are in line with the previous evaluation, cf. Cappelen et al (2008).

The implication of our results is that with respect to effects on firms' labour productivity, R&D projects with public funding are not significantly different from projects without.

5.3 External effects of SkatteFUNN

To consider the full economic effects of R&D we must consider potential externalities, which may cause large societal benefits. There are several possible spillovers from R&D. One potential spillover is the spreading of results or competence through collaboration in R&D projects or through staff mobility. Another possible external effect is that improved products lead to lower prices through market competition. Improved quality of products can also benefit the demand side. In the cases the demand side are firms, then lowered prices or improved products could benefit them in terms of increased productivity, margins or sales if they themselves improve their products as a result of their suppliers' innovation.

Baumol (2002) shows that the possible spillovers of R&D may vastly exceed the private gains. Bottazzi and Peri (2003) study regional spillovers on innovation and find that positive local externalities exist, but the effects are small. Meijers (2007) studies external effects of Information and Communication Technologies (ICT) on aggregate productivity and economic growth and finds significant positive effects, but with considerable time lag between time of investment and the time of the externalities. A more recent paper by Roper et al. (2013) find that externalities of openness in innovation are significant and that they are positively associated with firms' innovation performance.

To assess the magnitude and existence of external effects of R&D in Norway, we follow a classic approach in the literature, also used in the previous evaluation of SkatteFUNN.

5.3.1 Theoretical model and econometric specification

The idea is that the closer you are to other firms' R&D activity, the more you will benefit from it. In practice, this "proximity" can be measured as geographical proximity or in terms of industrial affiliation; firms are "close" if they are in the same industrial division. In theoretical terms, this means we assume that firms' production functions depend on aggregate R&D at the industry and regional levels. We will use county and industrial division, as specified by Industrial Classification SN2007, NACE Rev. 2.[98]

We calculate R&D intensities, meaning R&D investment per employee, by industry division and county. Then, these groups are ranked from high R&D intensity to low, using per centiles by industry-year and county-year. We use these rankings to make dummies, which are then interacted with R&D capital in our model specification in chapter 5.2.2. Thus, our model is simply an expansion of the above.

To conclude, we allow spillovers both in the geographical dimension and on the industry level, as well as allowing for these effects to differ between the two dimensions and between (i) those with

[98] http://www.ssb.no/en/klass/klassifikasjoner/6/

SkatteFUNN projects, (ii) those without SkatteFUNN projects but who have been R&D active at some point in the period we analyse and (iii) those with no R&D activity. Results are reported below, in relative to those who are in industries and counties with high R&D intensity.

5.3.2 Results

The results, displayed in table 5.10, show that for firms with no R&D capital, the effect of being in a county or industry with a low or medium level of R&D intensity relative to a high level of R&D intensity is not significant. That is, the results indicate no spillovers to firms without R&D activity.

Furthermore, the results show that both R&D capital and the share of highly educated employees in firms have positive and significant effects on labour productivity, as in the productivity analysis presented in chapter 5.2.3.

Table 5.10 Estimated productivity including external effects, 2003-2015. Dependent variable y = ln(Y/L).

	Models including external effects		
Explanatory variables	Combined effects	Only industry effects	Only county effects
y_{t-1}	0.377 (0.023)***	0.381 (0.023)***	0.373 (0.022)***
f_t	0.165 (0.016)***	0.168 (0.015)***	0.162 (0.016)***
f_{t-1}	-0.072 (0.014)***	-0.069 (0.014)***	-0.075 (0.016)***
d_low_industry	-0.187 (0.242)	-0.212 (0.245)	
d_med_industry	-0.002 (0.036)	-0.002 (0.036)	
d_low_county	-0.017 (0.095)		-0.02 (0.095)
d_med_county	0.146 (0.183)		0.142 (0.183)
d_low_industry x f_t	0.323 (0.528)	0.408 (0.531)	
d_med_industry x f_t	-0.093 (0.053)*	-0.089 (0.048)*	
d_low_county x f_t	1.247 (0.4)***		1.308 (0.391)***
d_med_county x f_t	0.02 (0.201)		-0.191 (0.164)
d_low_industry x d_skf x f_t	-0.25 (0.577)	-0.271 (0.577)	
d_med_industry x d_skf x f_t	-0.168 (0.06)***	-0.178 (0.06)***	
d_low_county x d_skf x f_t	-0.277 (0.144)*		-0.337 (0.142)**
d_med_county x d_skf x f_t	0.005 (0.049)		-0.036 (0.045)
h_t	0.217 (0.128)*	0.213 (0.127)*	0.212 (0.128)*
h_{t-1}	-0.028 (0.104)	-0.019 (0.104)	-0.021 (0.104)
Collaboration with R&ED[1]	0.019 (0.012)	0.018 (0.012)	0.019 (0.012)
Collaboration with other firms	0.011 (0.008)	0.01 (0.008)	0.012 (0.008)
Observations	11 304	11 304	11 304
Number of firms	2 149	2 149	2 149
Wald chi test	2 397.61	2 356.75	2 292.36
Sargan test (prob > chi)	0.053	0.054	0.045

[1] R&ED stands for research and educational institutions

Standard errors in parenthesis. * significant at 10 per cent, ** significant at 5 per cent, *** significant at 1per cent

Results for low and medium R&D intensity industries and counties are relative to high R&D intensity industries and counties.

Dummy variables for firm age, region, industry and time dummies are included, but not reported

d_low_industry = 1 if firm is in an industry with a low R&D intensity, d_med_industry = 1 if firm is in an industry with a medium R&D intensity, d_low_county = 1 if firm is in a county with a low R&D intensity, d_med_county = 1 if firm is in a county with a medium R&D intensity.

d_skf = 1 if firm has SkatteFUNN as main support in year t

The econometric analysis is inconclusive as to the external effects of R&D for those who are active R&D performers. While estimates show that firms in industries with medium R&D intensity have a relatively lower return to R&D capital than firms in industries with a higher level of R&D intensity, which is as expected, the estimates also indicate that firms in counties with a low R&D intensity have a relatively higher return to R&D than firms in counties with a high R&D intensity. This does not make sense logically, and we cannot say one estimated coefficient is "correct" or valid and one is not, within the same regression. This leads us to conclude that we are not able to quantitively assess the potential external effects.

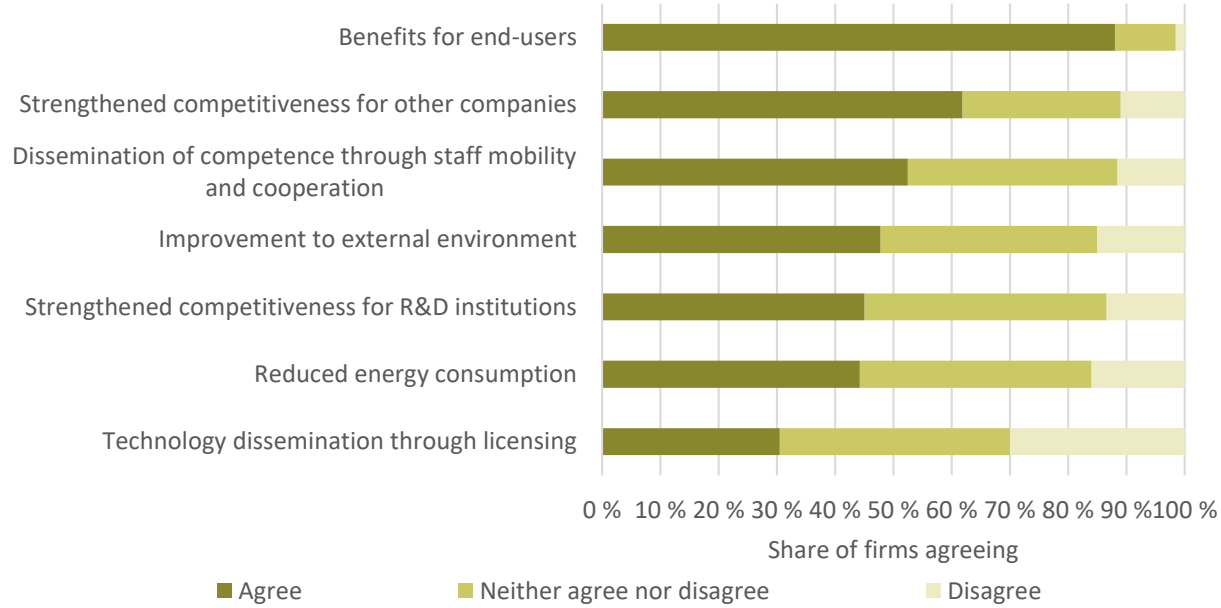
In Technopolis' web survey, firms were asked what impact their SkatteFUNN projects might have contributed to outside the firm. The most frequently reported impact was that the projects have benefited the firms' customers, mainly in terms of better products, cf. Figure 5.2. This is also linked to the second highest rated external impact, strengthened competitiveness for other firms.

Since the main customers of 78 per cent of the firms are other firms, improved products are instrumental in making their customers' operations more efficient or delivering better products to their customers, thus ultimately making also them more competitive.

Moreover, 45 per cent of respondents agreed that projects have contributed to strengthening of the competitiveness for R&D institutions (who have participated in projects).

Dissemination of competence through staff mobility and collaboration was the third highest rated external impact. A majority of SkatteFUNN projects involve some form of collaboration, either with an R&D institution or with other firms. Consequently, many opportunities for sharing of competence appear in projects, and we have noted that SkatteFUNN enables firms to expand projects from exclusively internal to involving external project partners.

Figure 5.2 Firm's view on SkatteFUNN project(s) contributing to impact outside the firm. N=575.



Source: Technopolis' user survey

An example of an important externality of innovation and development is when it leads to sustainable and environmentally friendly solutions. Firms were asked if their SkatteFUNN projects (e.g. through the products that has been developed) have had an impact in terms of improvement to the external environment (48% of survey respondents agreed) or reduced energy consumption, i.e. more efficient use of energy (40% of respondents agreed).

To illustrate how this has been achieved we present some examples from interviewed firms:

- Development of new equipment that make electric bikes more efficient and durable, thus enabling them to become a more attractive alternative to car travel (micro-enterprise within computer programming and consultancy)
- New products that enable increased use of wood-based materials in construction of buildings (firm within manufacture of wood and of products of wood and cork)
- Introduction of new chemical refrigerant mediums that lead to reduced CO_2 emissions (firm within manufacture of fabricated metal products, except machinery and equipment)
- Value added in reuse of residual materials from fish farming (micro-enterprise within social work activities without accommodation)

6 Types of R&D and collaboration in SkatteFUNN projects

We have assessed which types of R&D SkatteFUNN-projects lead to, the behavioural changes in the firms using SkatteFUNN and SkatteFUNN's impact on collaboration.

The most frequently reported types of R&D in our interviews are 'development of entirely new technical solutions' and 'testing and implementation of technical solutions new to the firm'. This indicates that SkatteFUNN projects are first, and foremost development projects directed towards improvement of the firms' products. Approximately 85 per cent of all approved projects are categorised as development. Successful R&D projects lead to innovations. We find that the median number of innovations attained per project is 1.62 per cent of the firms claimed that they achieved one or more innovation, and 14 per cent that they obtained one or more patents. SkatteFUNN projects seems to have the same possibility to result products new to the market, as projects supported by RCN, but a higher possibility than for projects supported by Innovation Norway.

A significant share of respondents in our survey state that the SkatteFUNN projects resulted in the firm being more inclined to apply for public funding for R&D, as well as carry out self-financed projects. The survey also show that R&D has gained increased importance for the firm, and that they are more likely to collaborate with others (both firms and R&D institutions) on R&D. Even though almost 60 per cent of respondents say that they are more prone to collaboration, we find no increase in collaboration between beneficiaries and research institutions in our analysis of descriptive statistics on applications and applicants.

6.1 Which types of R&D is stimulated by SkatteFUNN?

As part of the evaluation we identify what kind of R&D SkatteFUNN supports. We focus on basic research, applied research and development. This is a division known from the Frascati manual.

In this chapter we investigate the effects of SkatteFUNN with a broader set of indicators:

- R&D types:
  - Basic research
  - Applied research
  - Development
- Innovations
  - Product innovations
  - Process innovations
  - Innovations new to market
- Levels of intellectual property right:
  - Patent applications
  - Design applications
  - Trademark applications

To consider these matters, we use information from our survey and interviews and the R&D and innovation surveys conducted by Statistics Norway. We also use SkatteFUNN project data and data from the Norwegian Industrial Property Office.

6.1.1 Most projects are development of new technical solutions

Figure 6.1 shows the type of R&D conducted by firms in their latest SkatteFUNN project, as reported in our survey.

The most frequent type of R&D is development of entirely new technical solutions (67 per cent on average, and 78 per cent for firms in professional, scientific and technical activities), followed by testing/implementation of technical solutions new to the firm (47 per cent on average). Development of new/improved services or products were selected

by around a third of firms, and development to expand use of existing products by a quarter.

These results imply that the typical SkatteFUNN project has an applied focus directly connected to development or improvement of the firm's products. The same pattern is confirmed in our interviews, where a clear majority of firms relate project activities to their core products. This can explain why so many firms rate their projects as strategically important.

Firms that had multiple projects seem more likely to use some SkatteFUNN projects for more long-term strategic development, and other projects for more direct development of current products.

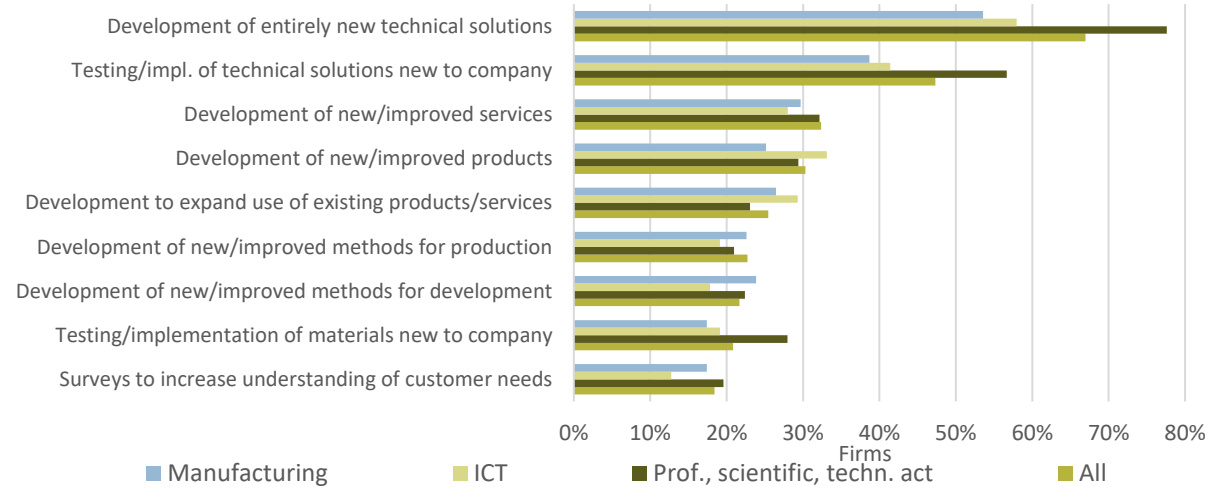
The interviews also indicate that most firms used SkatteFUNN for clearly defined development activities in the firm. In contrast, a few interviewees described a situation with several activities that formed the basis for a SkatteFUNN project

We have heard many examples by interviewees describing how SkatteFUNN is complementary to other public funding schemes. Combining SkatteFUNN with different schemes offered by Innovation Norway seems to be the most common complementarity. From officials in Innovation Norway, as well as through interviews with beneficiaries, we have learned that SkatteFUNN is seen as the first admission to the system of public R&D funding.

SkatteFUNN has a far broader target group, and only a minority of SkatteFUNN beneficiaries are eligible for support from Innovation Norway. The latter group is advised to apply for SkatteFUNN and supplement with funding from Innovation Norway. According to several interviewees, combining different public schemes for the same R&D project can either make administration more efficient for the user (if funding agencies are consistent in their reporting requests) or create extra administration (with lack of consistency).

The survey result that most SkatteFUNN projects are development projects is confirmed by the R&D statistics. Table 6.1 shows descriptive statistics on firms who reported their development, applied research and basic research cost shares in the R&D survey, a question that was asked biannually. Between 20 and 30 per cent of firms with main support from SkatteFUNN report this from 2003 to 2015.

Figure 6.1 Type of R&D conducted in latest SkatteFUNN project. N=581.



Source: Technopolis' user survey

Table 6.1 Development, applied research and basic research cost shares in firms with main support from SkatteFUNN. Percentages by internal R&D cost.

Year	Development cost share	Applied research cost share	Basic research cost share	No. of firms	Average no. of employees
2003	78,8	18,2	2,9	605	120
2005	73,6	22,3	4,0	594	103
2007	78,9	19,0	2,2	487	101
2009	78,2	17,6	4,2	466	109
2011	83,6	13,1	3,4	493	82
2013	79,1	17,5	3,4	555	84
2015	81,2	15,9	2,9	867	94

Only reported biannually in the survey
The statistics are weighted by internal R&D costs over sum R&D costs in firms with SkatteFUNN as main support before we take averages
Source: R&D survey, Statistics Norway

Firms who reported on their R&D type costs shares and have SkatteFUNN as their main public support have a development cost share of about 80 per cent on average over the last 8 years. However, some of these firms also have support from the Research Council of Norway (RCN), and these cost shares are therefore likely to be biased in the direction of research. However, we have data from RCN, who classify SkatteFUNN projects as either development or research projects. Here, we find that about 85 per cent of SkatteFUNN projects are development projects. The share of development projects varies between 80 and 90 per cent over the period 2002-2016.

6.1.2 Most projects lead to innovations

Successful R&D projects lead to innovations. SkatteFUNN beneficiaries report on results of their projects to RCN. In these data, we find that the median number of innovations attained per project is 1. Indeed, 62 per cent of all SkatteFUNN projects have resulted in one or more innovations. The median is also 1 for process innovations, and this type of innovations was achieved in about 27 per cent of all initiated projects. Missing observations on innovations account for the low share of process innovations, but missing observations are also present for other innovations in projects. Ignoring missing observations, the share of projects with one or more innovations is 84 per cent and the share of projects with one or more process innovation is also 84 per cent.

6.1.3 The same share of innovations new to market as RCN's R&D projects

In table 6.2, we show the shares of firms with innovations, by type of innovation and by main supporter (Innovation Norway, RCN or SkatteFUNN). The figure show that the share of firms receiving SkatteFUNN and being innovative in terms of patents or design is relatively stable and about as large as the share for projects supported by RCN in general. The share of innovative firms receiving support from SkatteFUNN or RCN is higher than the share for firms supported by Innovation Norway. The share of innovative firms is larger amongst those that received support, than those that did not.

However, it is important to interpret this data with caution. One problem is how we define main support. Some firms have more than one source of public support, which means that there can be cases where project results are connected to the wrong funding agency. Another issue is the fact that the R&D and Innovation surveys only sample the population among firms with 50 or less employees. This leads to a bias due to an underrepresentation of small firms in the sample, compared to that of the population. Also, since SkatteFUNN beneficiaries consist of a higher share of SMEs compared to RCN beneficiaries, the bias is amplified. Our interpretation is that the bias likely leads to underestimation of the share of innovative SkatteFUNN beneficiaries.

Table 6.2 Shares of firms with innovations, divided into three types of innovations and within groups of firms by main support; Innovation Norway, RCN or SkatteFUNN.

	Firms with main support from Innovation Norway			Firms with main support from RCN			Firms with main support from SkatteFUNN		
Year	Share of firms with product innovations	Share of firms with innovations new to market	Share of firms with process innovations	Share of firms with product innovations	Share of firms with innovations new to market	Share of firms with process innovations	Share of firms with product innovations	Share of firms with innovations new to market	Share of firms with process innovations
2004	8 %	5 %	5 %	25 %	14 %	16 %	22 %	12 %	15 %
2006	14 %	9 %	13 %	14 %	8 %	12 %	23 %	15 %	17 %
2008	10 %	7 %	7 %	18 %	13 %	15 %	24 %	14 %	17 %
2010	8 %	5 %	5 %	18 %	15 %	13 %	26 %	22 %	16 %
2012	7 %	5 %	6 %	15 %	13 %	12 %	22 %	20 %	14 %
2014	9 %	7 %	8 %	25 %	20 %	20 %	26 %	20 %	18 %

Only reported biannually in the survey
Source: Innovation survey, Statistics Norway

6.1.4 14 per cent of projects achieve one or more patents

The result of a R&D project can be protected in terms of secrecy or be officially registered as a firm patent, design or trademark. In terms of patent applications, firms with main support from SkatteFUNN have a lower share of patent applications per firm than firms with main support from RCN, but a slightly higher share than firms with main support from Innovation Norway.

We see the same picture for design applications. Figure 6.2 displays statistics on patent and design applications. Note that the abovementioned data issue pertaining to our classification of firms by funding agency is relevant here as well. Table 6.3 shows that patent applicants with main support from RCN has a higher patent application intensity than firms with other source of funding.

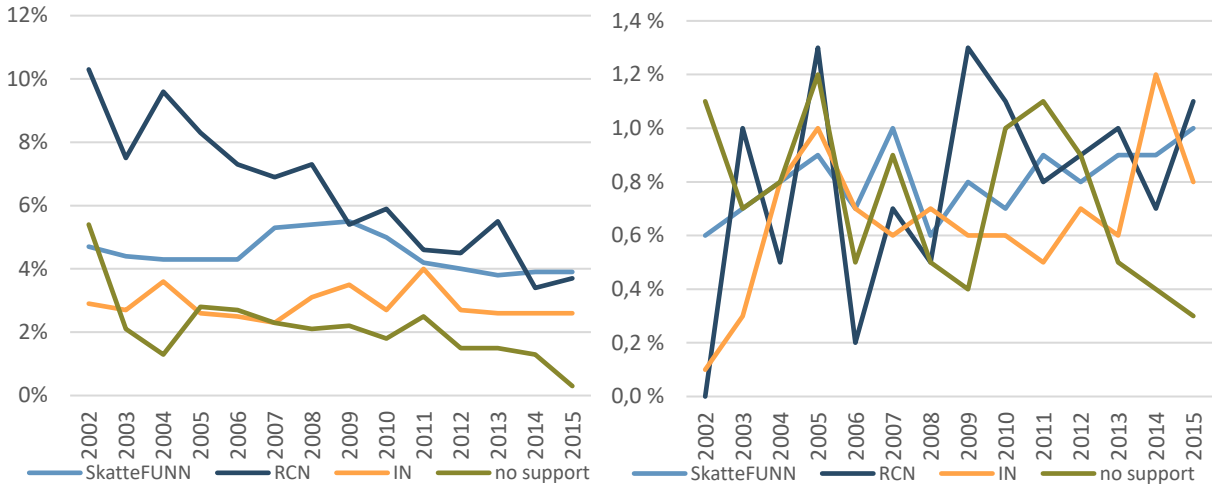
Of all initiated SkatteFUNN projects in the project data from RCN, about 14 per cent of projects achieve one or more patents. If we ignore missing observations in the beneficiaries' reporting of results, the share is 40 per cent.

Table 6.3 Average no. of patent, design and trademark applications for firms using property rights protection, by main source of support. 2013-2015.

	Main support: SkatteFUNN			Main support: RCN			Main support: IN		
Year	Average no. of **patent** applications for firms applying for patent	Average no. of **design** applications for firms applying for design	Average no. of **trademark** applications for firms applying for trademark	Average no. of **patent** applications for firms applying for patent	Average no. of **design** applications for firms applying for design	Average no. of **trademark** applications for firms applying for trademark	Average no. of **patent** applications for firms applying for patent	Average no. of **design** applications for firms applying for design	Average no. of **trademark** applications for firms applying for trademark
2013	2,17	1,38	1,51	2,82	1,22	1,77	1,51	1,09	2.12
2014	1,71	1,26	1,77	3,43	1,86	2,92	1,4	1,68	1.64
2015	1,66	1,31	1,80	3,53	1,09	3,03	1,94	1,21	1.63

Source: Norwegian industrial property office

Figure 6.2 Share of firms with one or more patent (to the left) and share of firms with one or more design applications (to the right), both by main support.



Source: Norwegian industrial property office

We only have data on trademark applications for 2013, 2014 and 2015. For these years, firms with main support from RCN also have a higher share of applications per firm with one or more applications, than that of firms with main support from SkatteFUNN, Innovation Norway and those with no support. However, among the latter three, firms with no support have a higher share than SkatteFUNN and Innovation Norway firms.

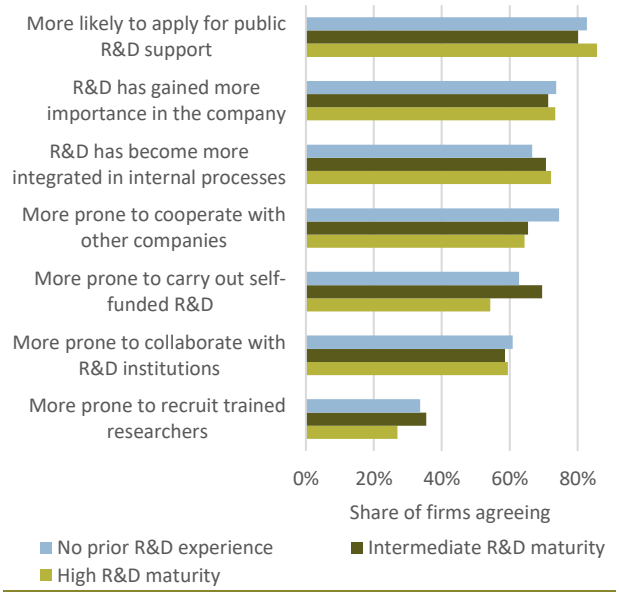
6.2 Behavioural changes in firms

In chapter 4 and 5, we find clear evidence of positive input and output additionality of SkatteFUNN. Firms invest more in R&D than they otherwise would have done, and productivity and innovation is higher than what it otherwise would have been.

Additionally, our survey sheds light on the behavioural changes that occur within firms that receive support. This is often referred to as a third form of additionality, namely behavioural additionality.

Regardless of industry and firms' R&D maturity, a significant share of respondents in our survey state that the SkatteFUNN project(s) has resulted in the firm being more inclined to apply for public funding for R&D, as well as carry out self-financed projects. The survey also show that R&D has gained increased importance for the firm, and that they are more likely to collaborate with others (both firms and R&D institutions) on R&D (see Figure 6.3). This is in line with the results in the previous evaluation of the scheme's behavioral additionality (Alsos, Clausen, Ljunggren, & Madsen, 2007).

Figure 6.3 Firms' view on changed behaviour due to SkatteFUNN. N=574.



Source: Technopolis' user survey

6.3 Collaboration in SkatteFUNN projects

Many SkatteFUNN projects involve some form of collaboration, either with an R&D institution or with other firms. As SkatteFUNN is designed today, collaboration with approved R&D institutions is encouraged with a doubled project cost cap compared to projects with no such collaboration, giving the firms the opportunity to purchase more external R&D.

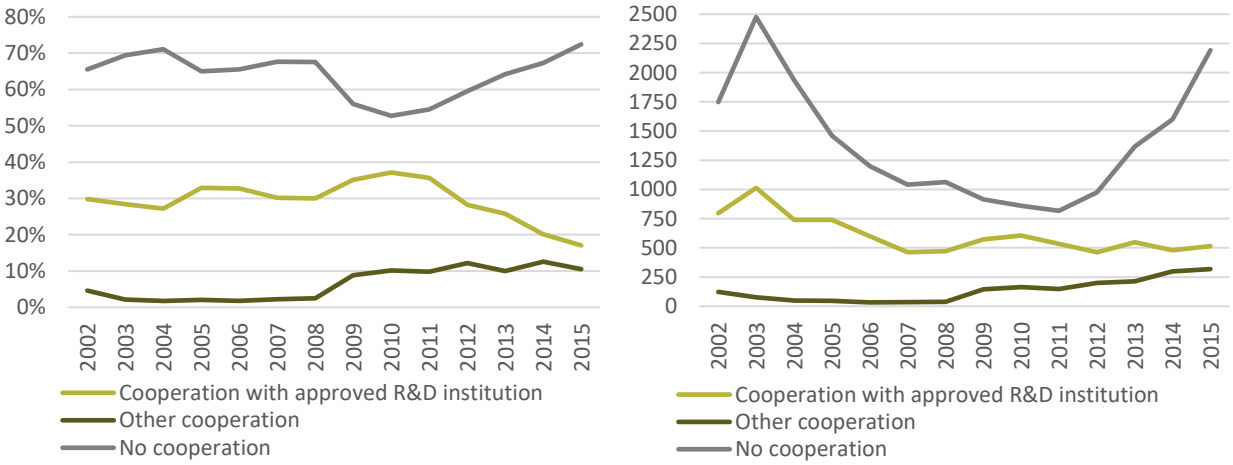
The reasons for stimulating collaboration are many; the assumption that collaboration leads to positive externalities through dissemination of results and knowledge sharing, the free rider problem (not participating in R&D, only copying others) and a more R&D intensive private sector.[99] Our results in chapter 5 demonstrate the importance of collaboration with respect to innovation output, where collaboration with other firms and in some cases with universities and other R&D institutes have a positive impact on the probability to innovate.

Between 2002 to 2015, 27 per cent of SkatteFUNN projects included collaboration with an approved R&D institution. The share of such collaborative projects among all approved projects varied around 30 per cent before 2012, after which this share has fallen, see the left panel of figure 6.4.

This decline must be considered an unwanted development, as the government aim to stimulate collaboration. However, as can be seen in the right panel of figure 6.4, the number of collaborative projects with an approved R&D institution has not experienced any significant change after 2007 and has been stable since then. Still, the question remains why there has not been an increase in the number of collaborative projects with approved R&D institutions, when the total number of projects has gone up and the total projects cost cap have been increased significantly.

If we separate projects by size, cf. figure 6.5, we see the same declining pattern in the share and number of projects that include collaboration with an approved R&D institution for all sizes. One exception is a slight increase in the largest projects that involve collaboration with an approved R&D institution, as seen in panel (c) of figure 6.5. However, the number of large projects without collaboration increased far more in 2013-2015 making the relative figures for collaborative projects quite modest.

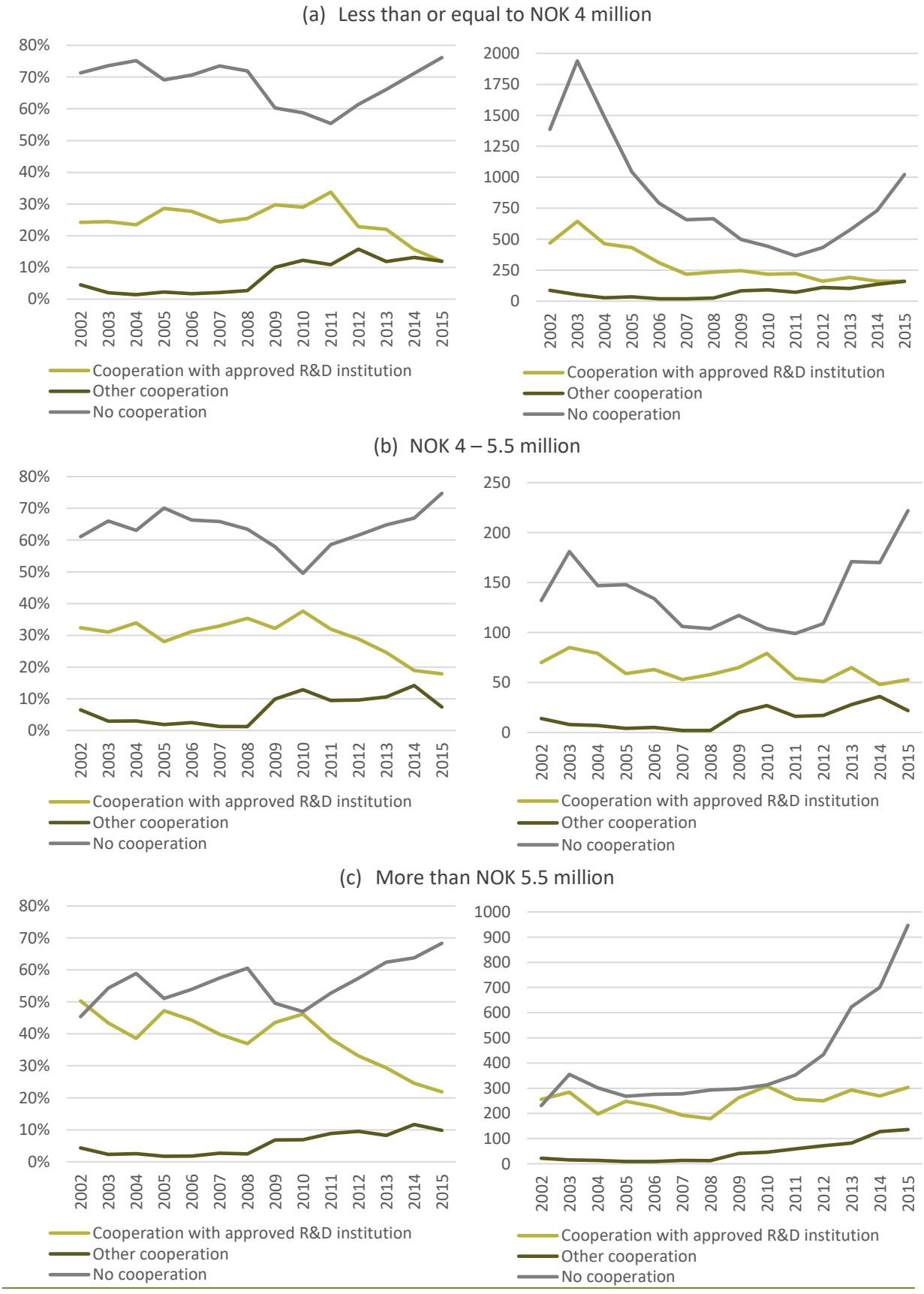
Figure 6.4 SkatteFUNN projects by type of collaboration. Share of projects to the right and number of projects to the left.



Source: Samfunnsøkonomisk analyse AS

[99] The latter being a stated political goal. See for example NOU 2000: 7 - Ny giv for nyskaping and St.meld. nr.20 (2004-2005) Vilje til forskning

Figure 6.5 SkatteFUNN projects by type of collaboration and project size. Share of projects within groups to the left and number of projects to the right.



Source: Samfunnsøkonomisk analyse AS

6.3.1 The scope of collaboration

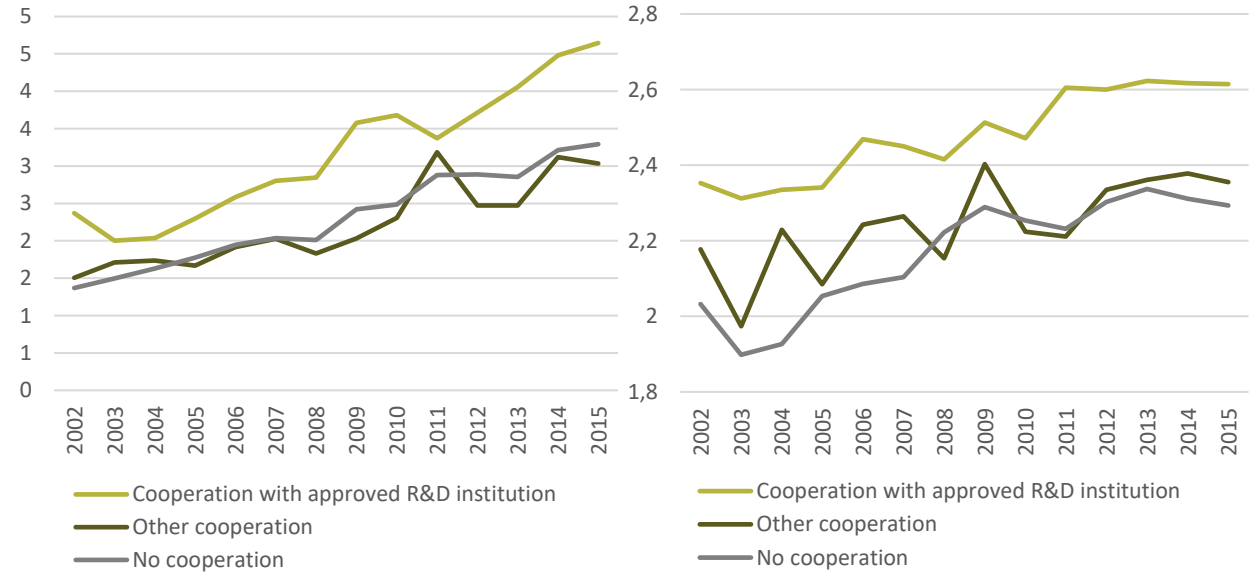
Though the number of collaborative projects with approved R&D institutions has been quite stable for almost ten years, these projects might have become larger, thus increasing collaboration in terms of project size, not number of projects. Table 6.4 demonstrates that collaborative SkatteFUNN projects have increased in both length and total budget per project year, especially after 2009, and more so than projects with no collaboration. However, they have not increased substantially relative to projects without collaboration, though they have done so slightly towards the end of the period (cf. figure 6.6).

Table 6.4. Descriptive statistics on SkatteFUNN applications by policy regime and collaboration

	Collaboration with approved R&D institutions				No collaboration			
Regime	No. of applications	Average project length (years)	Average deduction per project year (NOK thousand)	Average project budget per project year (NOK thousand)	No. of applications	Average project length (years)	Average deduction per project year (NOK thousand)	Average project budget per project year (NOK thousand)
2002-2003	1 809	2.33	358	2 164	4 224	1.95	245	1 444
2004-2006	2 079	2.38	388	2 287	4 595	2.01	309	1 758
2007-2008	936	2.43	448	2 823	2 103	2.16	354	2 024
2009-2010	1 178	2.51	545	3 578	1 773	2.29	429	2 423
2011-2013	1 545	2.61	590	3 717	3 159	2.30	504	2 870
2014-2015	994	2.62	772	4 567	3 792	2.30	615	3 259

Source: Samfunnsøkonomisk analyse AS

Figure 6.6 SkatteFUNN application data for three project types. Average budget divided by project length to the left and average project length in years to the right.



Source: Samfunnsøkonomisk analyse AS

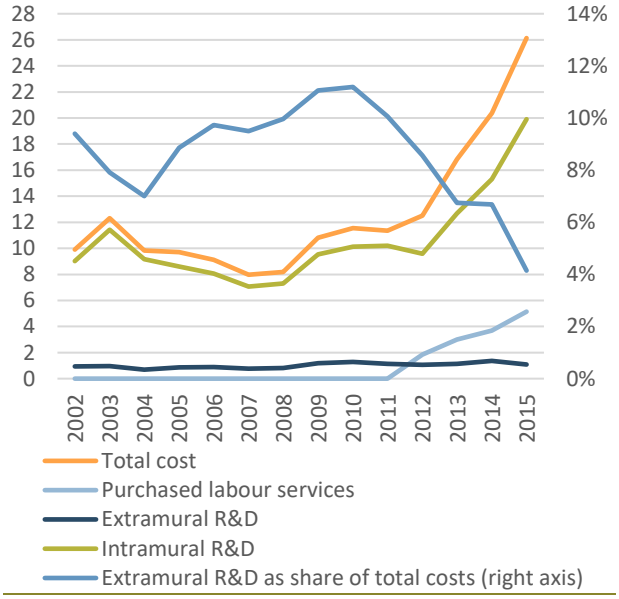
Figure 6.7 demonstrates that extramural R&D bought from R&D institutions has increased slightly since 2009. However, as share of the total costs it has decreased significantly after a peak in 2010.

The large increase in number of projects and the amount spent on intramural R&D must be seen in connection with the increased tax deduction allowed through the scheme in 2014 and 2015. Intramural R&D costs in 2015 were double those in 2012. However, we cannot see any reaction to the increased and doubled project cap for the extramural R&D in terms of increased collaboration.

Meanwhile, purchased labour services have become part of the SkatteFUNN application form. Figure 6.7 shows that since its inclusion in 2012, it has increased rapidly, though less than intramural R&D.

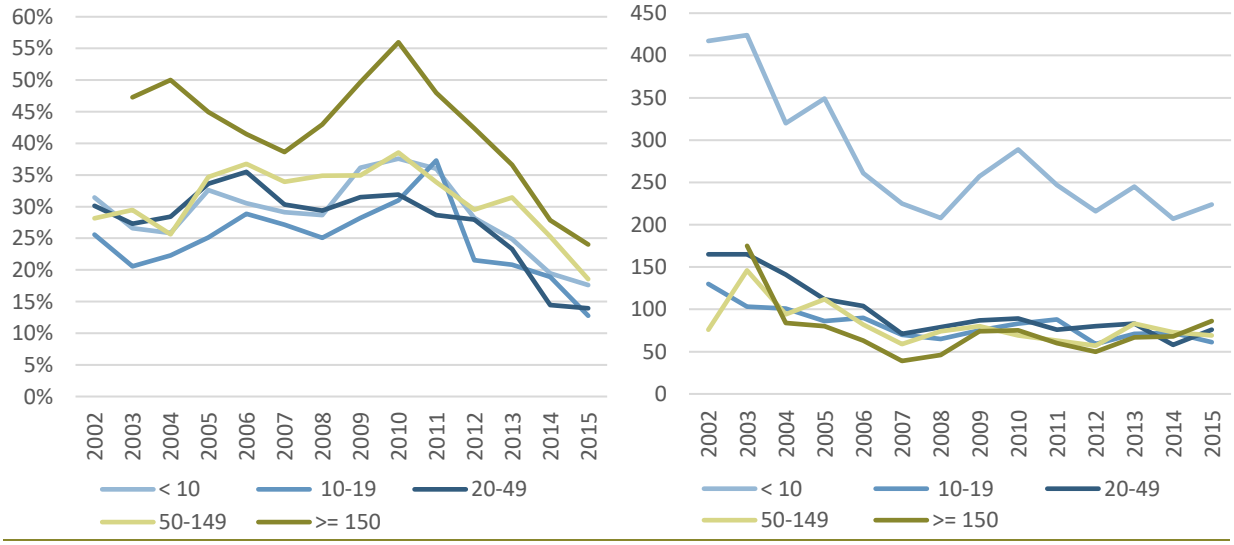
Since there is no significant increase in either the number of collaborative projects with an approved R&D institution or in the budgeted expenses on extramural R&D, we can refute the hypothesis that increased collaboration can be found in the increased size of projects with collaboration.

Figure 6.7 Budgeted project expenses and the cost share of purchased R&D from approved R&D institutions by year of application. Left axis: NOK million.



Source: Samfunnsøkonomisk analyse AS

Figure 6.8. Projects with collaboration with approved R&D institutions by number of employees in the project leader firm. Share of projects within groups to the left and number of projects to the right.



Source: Samfunnsøkonomisk analyse AS

6.3.2 Collaboration by firm size

To further check whether some specific groups of firms have developed their collaboration between 2002 and 2015, we divide firms by size. We observe that large firms (with 150 employees or more) has the highest share of collaborative projects with an approved R&D institution, see the left panel of Figure 6.8. These firms have consistently been the group with the highest propensity to collaborate with an approved R&D institution and the only group that increased the number of collaborative projects at the end of the period, see the rightmost panel of Figure 6.8. However, the share of such projects has declined notably since the peak in 2010.

The group of firms with less than 10 employees, is the largest group of SkatteFUNN beneficiaries and those with most collaboration projects. They also increased the number and share of collaboration projects with the cap increase in, but only for the first three years after the change. None of the groups (except the largest firms) seem to respond to the changes in the project caps in 2014 and 2015.

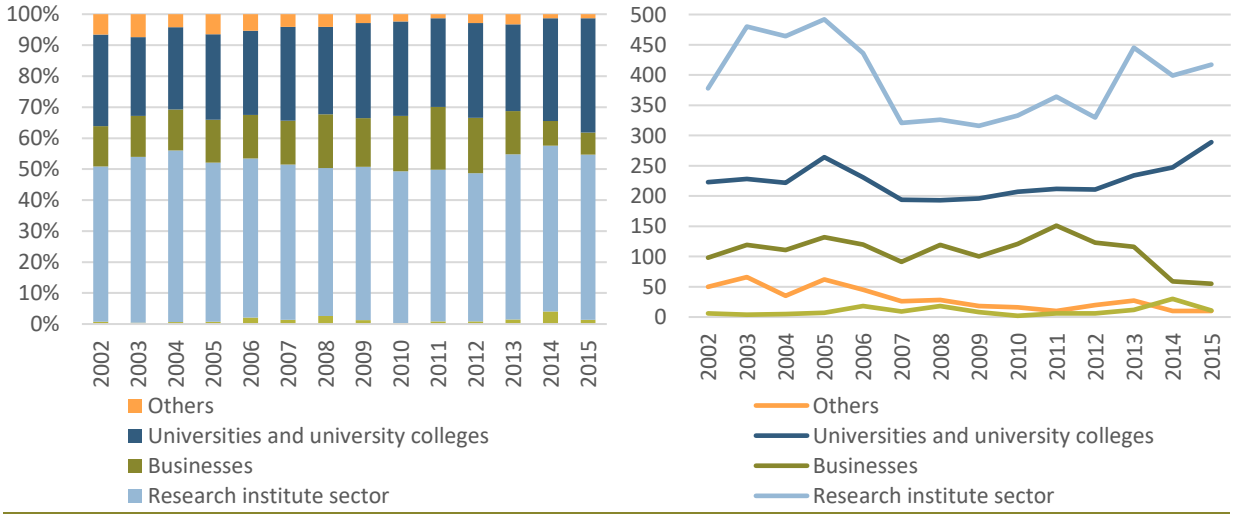
The shares of collaborative projects in SkatteFUNN for all firm sizes are in line with what is reported for Norwegian firms by the R&D survey conducted by Statistics Norway.[100] Hence, we do not observe higher collaboration intensity among SkatteFUNN firms compared to R&D firms in general.

6.3.3 Collaboration by type of collaborator

Looking closer at who the approved R&D institutions are and the frequency of collaboration, it is clear that the research institute sector has been, and is, the most predominant R&D partner, followed by universities and university colleges and firms. On average, over the period between 2002 and 2015, research institutes have participated in 51 per cent of projects with an approved R&D partner, while universities and university colleges have been partners in 30 per cent, see the left panel of figure 6.9.

The shares have been relatively stable in the period 2002-2012, but in recent years both the number and share of projects where firms act as approved R&D partners in projects is significantly lower. On average, in the period 2002-2012, firms collaborated in 16 per cent of projects as an approved R&D partner, but this share was only 8 per cent in 2014 and 7 per

Figure 6.9 Collaborating R&D institutions by sector. Share of projects within groups to the left and number of projects to the right.



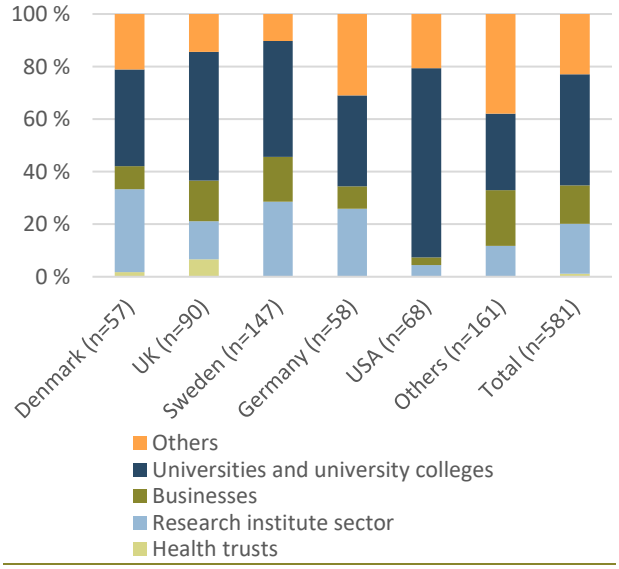
Source: Samfunnsøkonomisk analyse AS

[100] Click here to see the whole survey.

cent in 2015. This reduction could be due to changes in approved firms by RCN or that project leaders look to universities and university colleges and/or research institutes instead, since their share of projects have increased since 2012.

Some R&D institutions participating in projects are foreign. The most predominant countries are Sweden, the UK, USA, Germany and Denmark, see figure 6.10. Among the foreign R&D institutions, universities account for 42 per cent of the projects with a foreign partner in the years 2002-2015.

Figure 6.10 Cooperating foreign R&D institutions by sector. Top 5 countries, others and total. Sum of 2002-2015.



Source: Samfunnsøkonomisk analyse AS

6.3.4 Geographical distribution

As noted in chapter 5, eastern Norway (Oslo, Akershus, Østfold, Hedmark, Oppland, Buskerud, Telemark and Vestfold) is the region with the highest share of SkatteFUNN projects, followed by western and central Norway.

Separating beneficiaries by county, we see that these shares have been quite stable over time. On average over the whole SkatteFUNN period, the highest share of SkatteFUNN firms are based in Oslo, with about 17 per cent, followed by Rogaland with 10 per cent and Sør-Trøndelag, Akershus and Hordaland with around 9 per cent each.

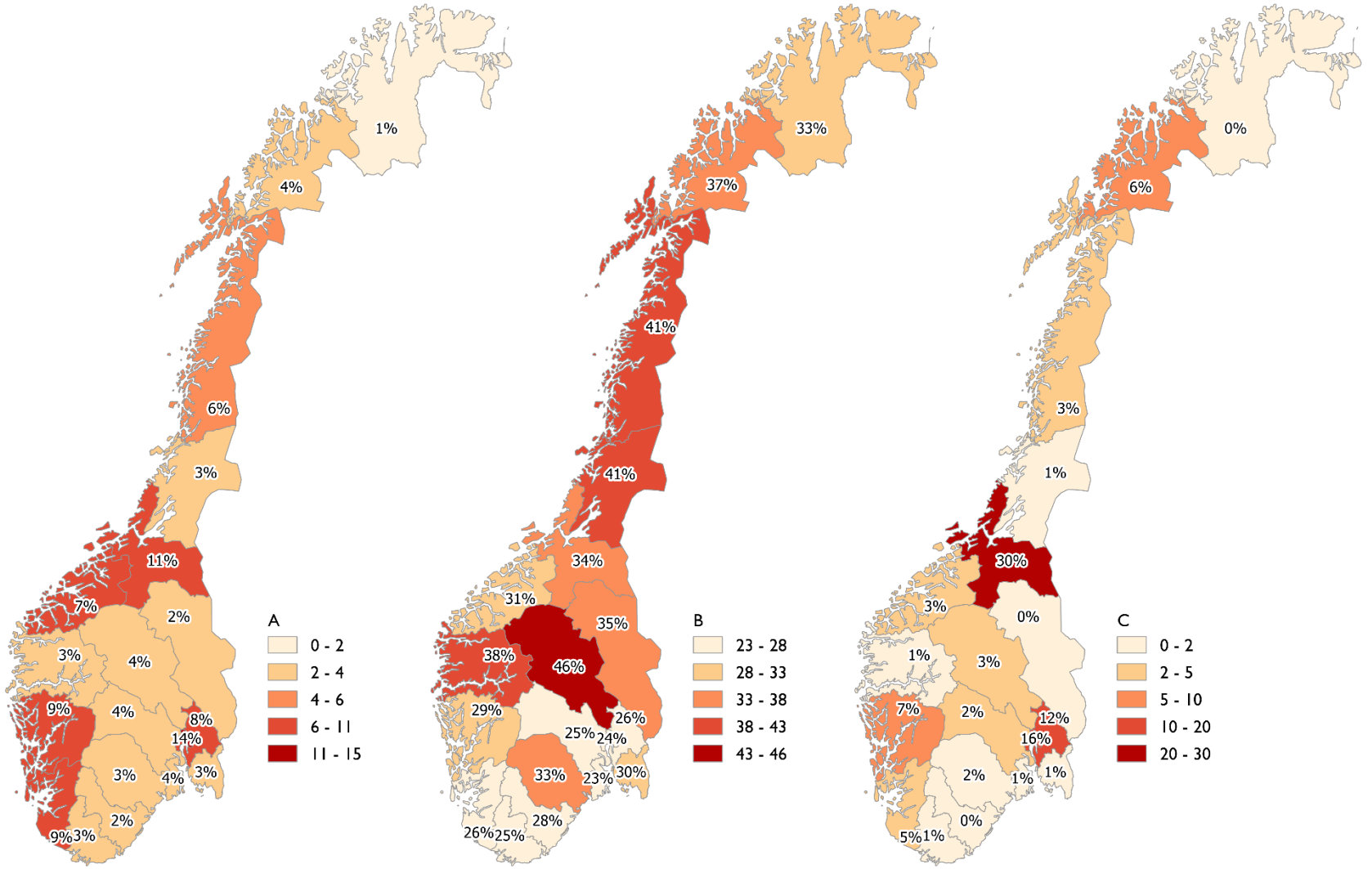
Looking at the geographical distribution of collaborative projects with approved R&D institutions, we mostly observe the same geographical distribution as project in general, with no clear locational patterns in the data (see Map A of Figure 6.11).

It is clear that more peripheral regions have higher shares of collaborative projects with approved R&D institutions, although the shares in all counties vary a lot over the period 2002-2015. In Oslo and Akershus, the share of collaborative projects is lower than for example in Oppland, Nord-Trøndelag and Nordland. Troms also has a relatively high proportion of collaborative projects (see Map B of Figure 6.11).

These numbers make sense, since small firms without intramural R&D capabilities are more likely to be located in rural counties of Norway, while firms with these capabilities inhouse are mostly located in the large cities. Troms stands out as a knowledge and collaboration intensive county.

As to the location of the approved R&D institutions, Sør-Trøndelag sticks out as having the R&D institutions with the highest share of projects in the period 2002-2015 (see Map C of Figure 6.11). SINTEF and NTNU (the Norwegian University of Science and Technology) were the most frequent participants in this county. Our data shows these two institutions are predominant participants in projects with support from other public R&D support schemes as well. R&D institutions located in Sør-Trøndelag were present in around 30 per cent of projects with approved R&D institutions. R&D institutions in Oslo and Akershus were present in 16 per cent and 12 per cent of collaborative projects in the period, respectively.

Figure 6.11 **Map A**: SkatteFUNN firms with cooperative projects by county and collaboration frequency. **Map B**: SkatteFUNN firms with cooperative projects by county and collaboration intensity. **Map C**: Approved R&D institutions by county and collaboration frequency.



6.3.5 Collaboration reported by SkatteFUNN firms in the survey

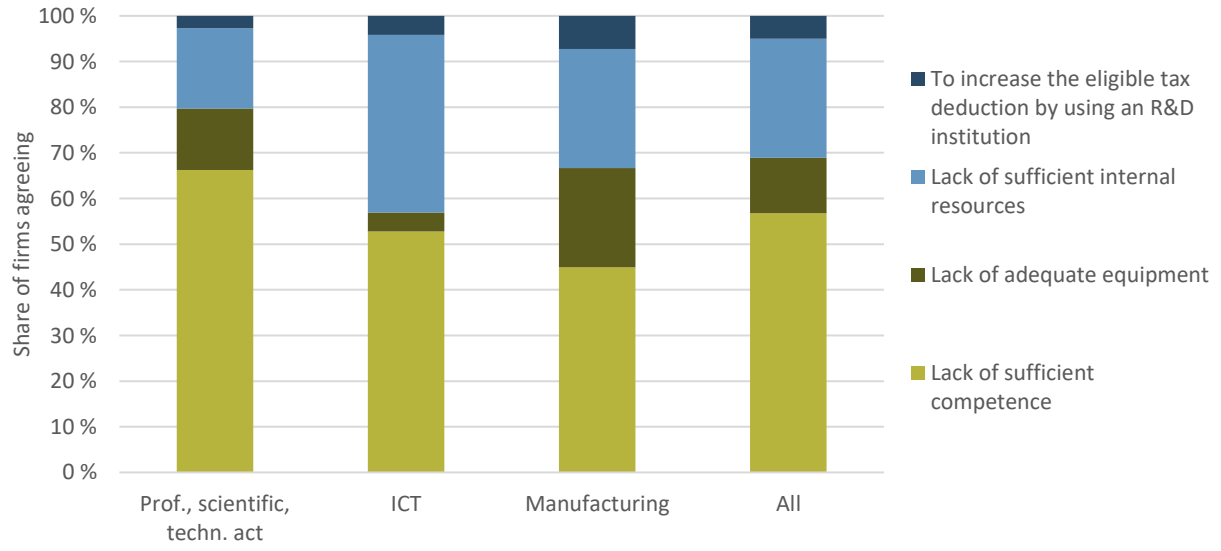
Our survey of SkatteFUNN beneficiaries (cf. Appendix A) reports that the primary rationale for firms to buy external R&D services is lack of sufficient competence (57%), followed by lack of sufficient internal resources (26%) and lack of adequate equipment (12%), see the final column in Figure 6.12.

A breakdown by private sector shows that firms supplying professional, scientific and technical activities require external competence to a greater degree than others. Few ICT firms enlist external services to access equipment, but rather for competence and resource reasons. Firms in manufacturing buy external services less for competence reasons but are the most prone to do so to access equipment. A not insignificant 7 per cent of firms in manufacturing motivate their outsourcing by increasing the amount of their tax deduction. The same question broken down by firm size reveals that micro-enterprises mainly motivate their outsourcing with lack of competence, and the largest firms with lack of equipment.

If we then move on to how SkatteFUNN projects affects a firm's propensity to collaborate, Figure 6.13 illustrates that around two-thirds of firms' report having established/strengthened their collaboration with R&D institutions. This tendency is notably more common in high-additionality projects (projects that would not have been conducted without SkatteFUNN support).

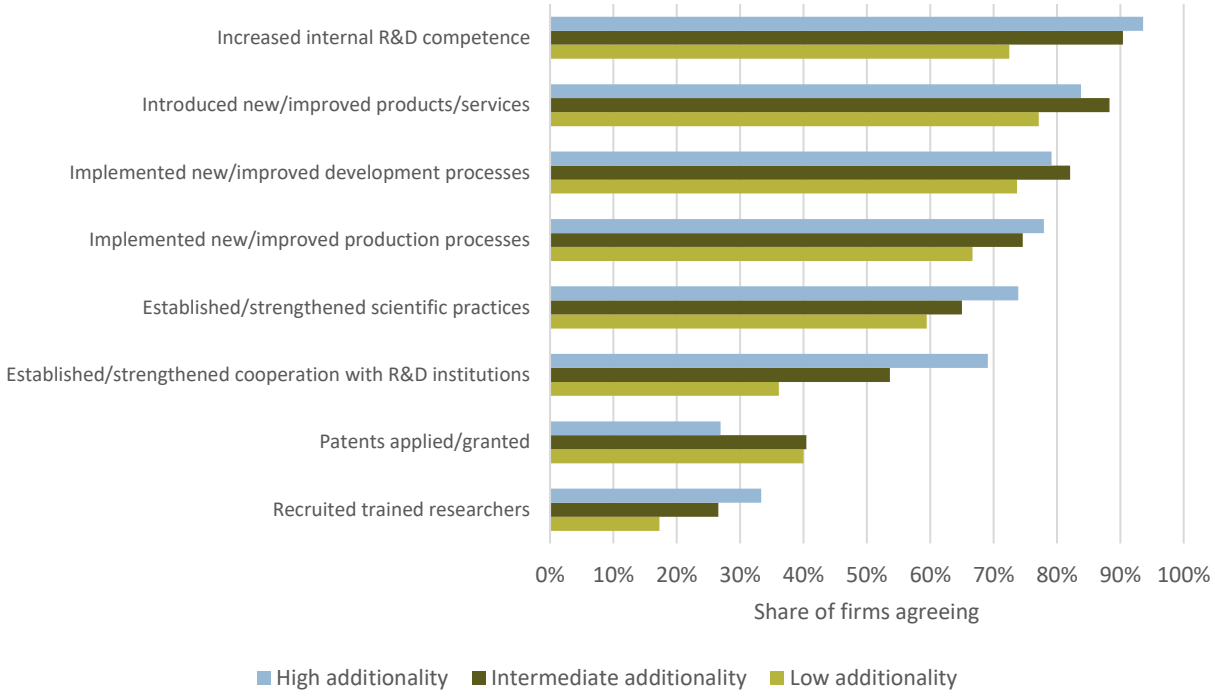
Two-thirds of firms also report that SkatteFUNN project(s) has made them more prone to collaborate with other firms, six firms in ten that they have become more prone to collaborate with R&D institutions, and an equal proportion made them more prone to carry out self-funded R&D projects, see Figure 6.14. This is corroborated by many other studies that have shown that successful R&D collaboration and enhanced networks increase firms' long-term R&D activities. There are in these respects only minor differences in responses between firms of different sizes and in different private sectors.

Figure 6.12 Firms' rationale for buying external R&D services. N=567



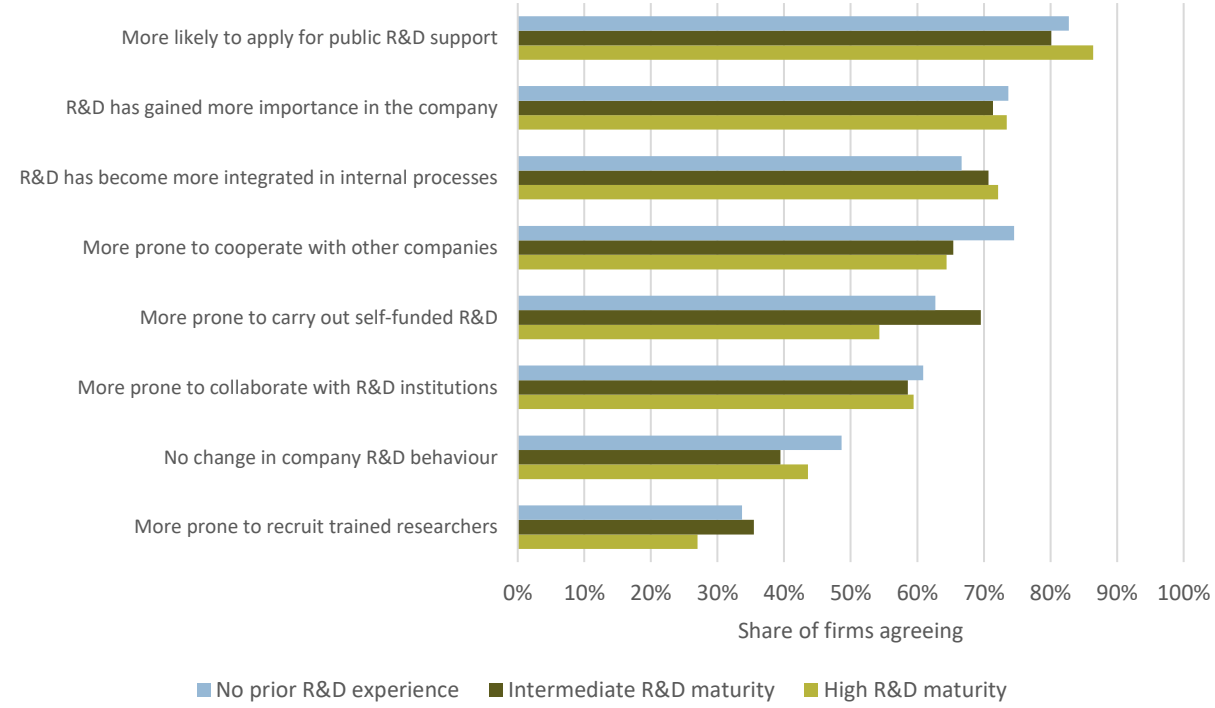
Source: Technopolis' user survey

Figure 6.13 Firm's view on SkatteFUNN project(s) contributing to results for firm. N=572



Source: Technopolis' user survey

Figure 6.14 Firm's view on SkatteFUNN project(s) contributing to changed firm behaviour. N=574



Source: Technopolis' user survey

6.3.6 Concluding remarks

Even though almost 60 per cent of respondents in our web survey say that they are more prone to collaborate with R&D institutions in the future, we find no increase in such collaboration in our analysis of descriptive statistics on applications and applicants through 2002-2015.

One important reason for such a dichotomy is that around half of all SkatteFUNN beneficiaries have only had one SkatteFUNN project, so even though they might collaborate in the future we cannot capture it through analysis of past SkatteFUNN projects only. Moreover, stating that you consider yourself more likely to collaborate with a R&D institution in the future may be a long step away from actually doing so, particularly for SMEs (that dominate in SkatteFUNN), which tend to have very intermittent (and short-term) R&D needs.

A large number of previous studies have convincingly shown that once a firm starts to collaborate with R&D institutions it continues to do so. However, this tendency is strongest for larger firms that exhibit a more continuous R&D engagement. Moreover, recent studies on Norwegian firms' use of public R&D funding instruments suggest that SkatteFUNN has often been an "entry" point for subsequent use of other available instruments, both Norwegian and international.[101]

We know from chapter 5 that the impact of collaboration with research and educational institutions is positive for firm productivity, but weak in the case of innovation. While Gulbrandsen and Smeby (2005) also demonstrate productivity gains of collaboration for universities, firms still prefer to collaborate with other firms and just to some extent with universities (NIFU, 2017).

As the Science and Technology Indicators for Norway 2014 (NIFU) demonstrates, collaboration with customers and suppliers has increased over time, while collaboration with universities and R&D institutes has remained unchanged between 2008 and 2013 despite of all efforts of R&D supporting schemes to stimulate such collaboration.

A possible explanation could be that firms who might benefit from the type of collaboration that SkatteFUNN aims to stimulate are already involved in this collaboration, and that making collaboration in SkatteFUNN projects more economically beneficial therefore has not and will not lead to more collaboration. Another explanation could be the firms' internal policy regarding the protection of ideas in form of secrecy and hence a reluctancy for collaboration.

The descriptive analysis leads us to the main conclusion that SkatteFUNN in general, and specific increases in the cost cap for extramural R&D, have not stimulated collaboration as measured by official statistics. However, the survey results suggest changes in the direction of better understanding of the gains of such collaboration by firms and, hence, that we will perhaps see more collaboration with R&D institutions in the future (while not necessarily only in SkatteFUNN projects).

[101] Rybalka, M. (2016): Offentlig støtte til privat innovasjon – omfang, varighet og gjengangere, Økonomiske analyser 2016/2, Statistisk sentralbyrå, Oslo.

Åström, Storsul Opdahl, Håkansson and Bergman, «Casestudieanalyse av et utvalg prosjekter i programmet Brukerstyrt innovasjonsarena (BIA)», RCN, 2017.

7 SkatteFUNN and alternative measures

A major advantage of SkatteFUNN, compared to many other national schemes, is its low administrative costs. That SkatteFUNN is available to all, without a time consuming and costly application process for the authorities as well as firms. The process involving application for R&D schemes is often a barrier for SMEs in particular, with little or no experience with such processes.

More than 70 per cent of the firms in our survey rated SkatteFUNN as easier to apply for and having more reasonable reporting requirements, relative to other R&D-oriented schemes. Thus, most firms consider the scheme's administrative burden as low, compared to other schemes.

We also find that despite the relatively low administration costs, SkatteFUNN has not lower additionality than other schemes. By comparing our results with the results of studies on the additionality of R&D subsidies we conclude that SkatteFUNN's additionality is higher.

SkatteFUNN entitles all firms the right to tax deductions for R&D expenses, provided that their project aims at creating new knowledge or new experiences in association with development or improvement of goods, services or processes. That fulfilment of a set of criteria provides firms with the right to receive a tax deduction makes SkatteFUNN different from most other R&D supporting schemes. In NOU 2000: 7, the green paper that laid the foundation for SkatteFUNN, the Hervik committee underlined the importance to create a scheme to give firms right to R&D support based on objective criteria. The argument was that a rights-based scheme with a simple approval process would make it easier for each individual firm to plan its R&D efforts. This was thought to be especially important for SMEs.

In this chapter we discuss to what extent the SkatteFUNN-beneficiaries actually see this as an important feature of the scheme. We do also discuss this feature's influence on the impact of SkatteFUNN and the consequence of changing SkatteFUNN to an application-based scheme.

7.1 How does SkatteFUNN differ from other R&D enhancing schemes?

An immediate advantage of a rights-based scheme, compared to an application-based schemes, is that it provides low administrative costs for both applicant and application processor. Only the terms of support are up for consideration. This will clearly reduce time consuming and costly application processes.

The right to support also move the ultimate decision of what the R&D activity should consist of from policy makers to the market. From the firm's perspective a right to support will make it easier to link the R&D decision to the firm's strategic interests.

The cost of moving the decision of R&D activities to the firms is that it does not help developing a long-term policy for strategic knowledge building in the society. That's why the Hervik committee narrowed the proposal for SkatteFUNN to smaller R&D projects. Support for larger R&D projects in firms was left to traditional direct support schemes administrated by the Research Council of Norway (RCN).

It is not obvious that the government has an information advantage as to which projects will succeed or potentially bring highest social gains (Hall and Van Reenen, 2000). But it is more legitimate to emphasize national research strategic considerations when it comes to support larger projects. In this way, SkatteFUNN contributes to balancing the importance of low administrative costs in supporting

R&D in firms and national research policy considerations within a single system of public support for private R&D.

7.2 SkatteFUNN among other R&D schemes

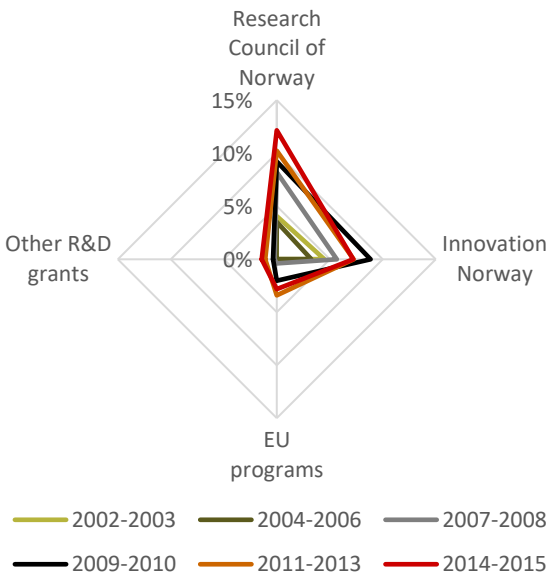
A first look at SkatteFUNN beneficiaries' use of other schemes, indicate that the share of firms receiving support from Innovation Norway and RCN has increased over time. However, as we will discuss below, there are several possible explanations for this, which are not necessarily related to the beneficiaries' use of SkatteFUNN.

To distinguish between the effect of SkatteFUNN and other schemes aiming to impact firms' R&D investment, it is interesting to know the extent of support from other (relevant) public funding schemes. In addition, the extent of support from other schemes can be considered a result of the scheme itself. That is, it is conceivable that SkatteFUNN projects increase firms' R&D maturity, which in turn may lead them to apply for public funding of larger and more complex R&D projects from funding agencies such as RCN or various EU programs (e.g. Horizon 2020). This is sometimes referred to as climbing the "research ladder".[102]

Earlier studies indicate that it is difficult to document firms' development in the so-called research-ladder. Furthermore, given that all firms with an approved R&D project can apply for SkatteFUNN, they may receive an R&D tax credit while also receiving support from other schemes "higher" up the ladder.

In the following we document SkatteFUNN beneficiaries' support from other public schemes. We are not able, within the scope of this evaluation, to determine the causal link between changes in the use of other schemes and SkatteFUNN. The analysis below should therefore be read as a clarification of what characterises SkatteFUNN beneficiaries among other public funding schemes.

Figure 7.1 Firms by additional sources of funding. Share of total.



Sources: Statistics Norway and Samfunnsøkonomisk analyse AS

7.2.1 Relative representation of other schemes

Norway has several different schemes aimed at stimulating R&D and innovation. Most of these are administered by RCN, Innovation Norway and, some, by Siva (the Industrial Development Corporation of Norway). The various schemes are aimed at correcting various types of market failures and target different types of firms. In addition, the beforementioned funding agencies, as well as others, offer schemes that are intended to promote economic growth in general.

There are 12,365 unique limited liability firms (LLC) with an R&D tax credit (SkatteFUNN) in our data for 2002-2016.[103] Of these, 5,016 (41 per cent) have

[102] Not necessarily a well-established expression but it is a good illustration of how to imagine firms develop in their use of public schemes.
[103] For database description see Appendix C (i.e. Database for public support schemes). There are in total 13 223 unique beneficiaries of SkatteFUNN. However, we restrict the sample to limited liabilities to ensure that the sample is comparable with the sample in the econometric analysis.

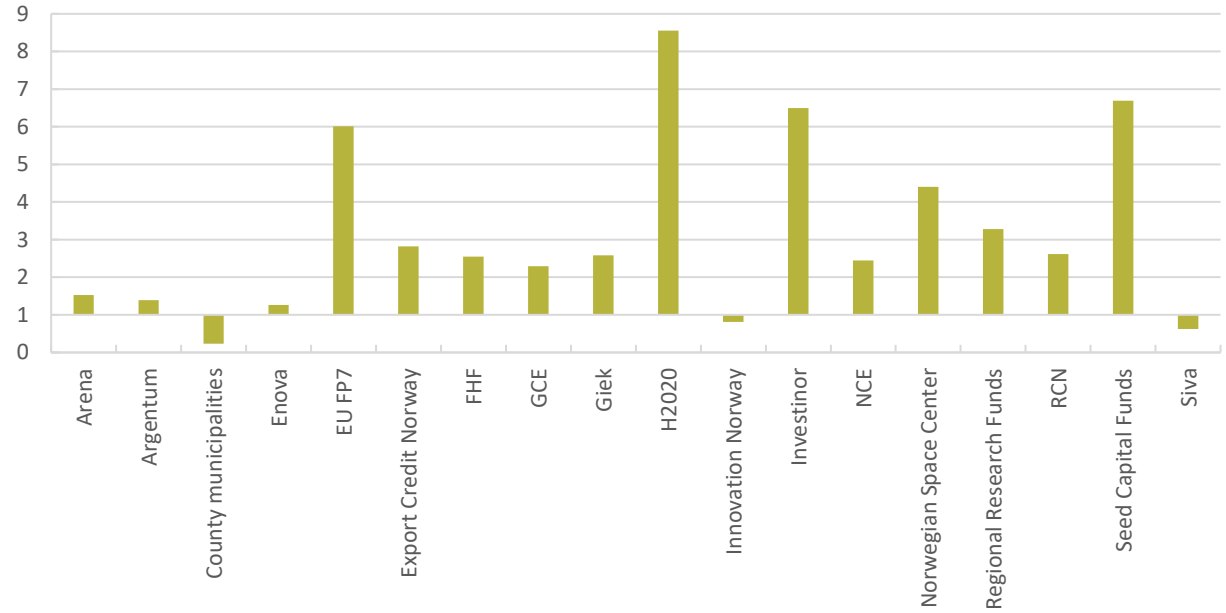
not received support from any other scheme than SkatteFUNN. Compared to other schemes in our data, SkatteFUNN has a relatively low share of firms with support from other public schemes.

More than 70 per cent of the firms in our survey rated SkatteFUNN as easier to apply for and having more reasonable reporting requirements, compared to other R&D-oriented schemes. Thus, most firms consider the scheme's administrative burden as low, compared to other schemes. Furthermore, SkatteFUNN is preferred by most respondents for its high rate of project approval and is considered the most well-adapted scheme for the respondents' needs and working practices.

To assess whether some funding agencies stand out among SkatteFUNN firms with support from others, we compare each agency's share of these firms with the agency's share of other supported firms (that have not received an R&D tax credit). Doing this, it is apparent that most funding agencies make up a larger share among beneficiaries of SkatteFUNN than for other firms receiving public support (cf. Figure 7.2).

EU's 7th framework program (EU FP7) and Horizon 2020 stand out as other sources of funding for R&D projects among beneficiaries of SkatteFUNN.[104] Other funding agencies with relevant R&D schemes, such as RCN, Regional Research Funds

Figure 7.2 Relative representation of other funding agencies among SkatteFUNN users. Funding agencies' relative share.[1] Total[2] for 2000-2016



Source: Samfunnsøkonomisk analyse AS

1) Relative share per agency indicates the relationship between the agency's share of firms in the sample (limited liabilities with R&D tax credit from SkatteFUNN) and the agency's share of all other limited liabilities with support from the respective agency. A factor greater than 1 indicates that the agency is "overrepresented" among SkatteFUNN beneficiaries and vice versa.

2) Sample only include limited liability firms (excl. research institutes organised as limited liabilities). Schemes funding agriculture activities and energy efficiency measures are excluded.

[104] These programs can be considered as the same source of funding, as Horizon 2020 is EU FP7's "successor".

and the Norwegian Space Centre, also make up a relatively large share of the support to SkatteFUNN beneficiaries.

In addition to being "overrepresented" among R&D-oriented schemes, funding agencies providing equity investment, such as Investinor and Innovation Norway's Seed capital funds, constitute a relatively large share among SkatteFUNN beneficiaries that receive support from several sources.

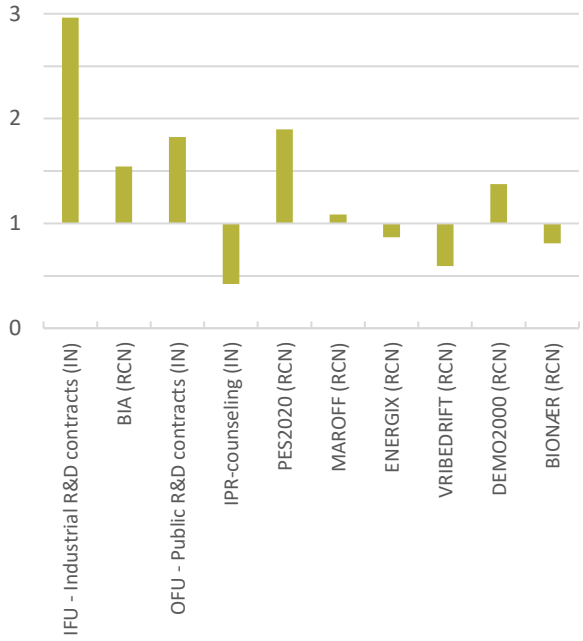
In our survey, respondents rate Innovation Norway's schemes as the most relevant, after SkatteFUNN, followed by RCN and private capital.

Given the nature of SkatteFUNN, the relatively high representation of other funding agencies supporting R&D, is most likely because firms that have approved R&D projects with funding from other sources also apply for tax credit on their R&D expenditures.

If we only look at schemes with similar objectives as SkatteFUNN, that is schemes aimed at increasing firm's R&D, the share of SkatteFUNN beneficiaries only using SkatteFUNN increases to 65 per cent. Measured in number of SkatteFUNN beneficiaries receiving support from other schemes with similar objectives as SkatteFUNN, Innovation Norway's "industrial R&D contracts" is the most used (cf. Figure 7.3). For most years this scheme has existed, SkatteFUNN has been a prerequisite for receiving funding. The same holds for "public R&D contracts". Thus, interaction with these schemes is not surprising.

Of the ten most used schemes, seven are R&D programs in RCN.

Figure 7.3 Top 10 public schemes for SkatteFUNN beneficiaries (ranked by no. of firms from left to right). The schemes' relative share.[1,2] Total for 2000-2016[3]



Source: Samfunnsøkonomisk analyse AS
1) See explanation of the relative share in Figure 7.2
2) BIA, PES2020 - Project Establishment Support for H2020, MAROFF - Innovation Programme for Maritime Activities and Offshore Operations, ENERGIX - Large-scale programme for energy research, VRIBEDRIFT - Regional R&D&I, DEMO2000 - Competitiveness in the oil and gas sector, BIONÆR - Sustainable Innovation in Food and Bio-based Industries
3) The period varies for the different schemes, but they have been available to all in the period they have existed

7.2.2 Changes in interaction with other schemes

As mentioned above, one could think that SkatteFUNN would lead firms to apply for other types of public R&D funding. However, SkatteFUNN firms that receive support from other funding agencies are firms that also continuously use SkatteFUNN. It is not unusual that projects are funded by both RCN and SkatteFUNN, if the funding is within the allowed limit for public funding.

Given that projects receive funding from several schemes, it is difficult to trace a firm's development along the "research ladder". If we look at which schemes the SkatteFUNN beneficiaries have used

before and after their first SkatteFUNN project, we don't find a significant change in the type of schemes they use. It may be possible to document a project or idea's advancement from SkatteFUNN, to application-based research funding from RCN (or EU) and lastly support for commercialisation, but this is beyond the scope of this evaluation.

It is worth mentioning that it is challenging to quantify changes in the use of public schemes adequately. Firstly, our data on support from public schemes starts in 2000. For firms that started their first SkatteFUNN project in 2002, the period of data is much longer after their first project than before. The increase in volume can therefore be a mere consequence of the number of years with the possibility of receiving support. Secondly, there has been an increase in the number of schemes offered by those funding agencies that have existed throughout the data period (Innovation Norway and RCN), as well as an increase in the number of funding agencies.

7.3 Our survey of beneficiaries indicates few barriers to use SkatteFUNN

As part of the survey of SkatteFUNN beneficiaries done in this evaluation, we have asked how they experience the practice of the scheme compared to other schemes for support for R&D. A convincing majority of firms were positive regarding the application and reporting process.

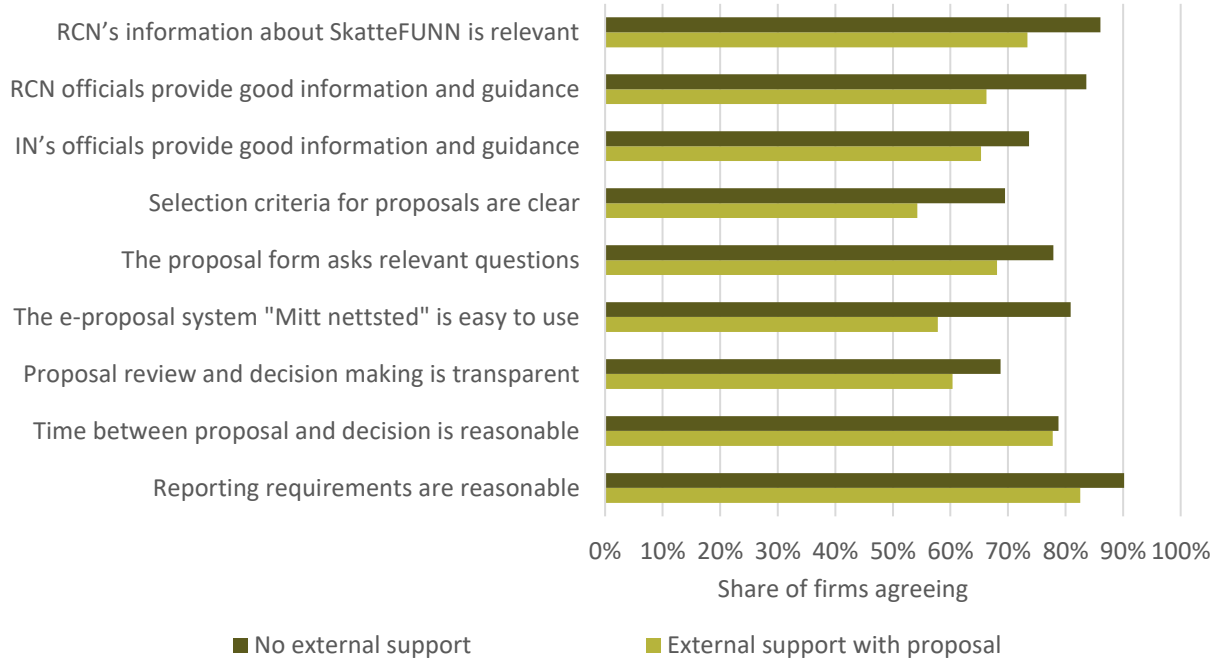
Most firms were also satisfied with the information and guidance provided by both RCN and Innovation Norway officials about the scheme, but RCN officials received slightly more positive assessments (77 per cent agree that RCN officials are helpful, compared to 71 per cent for Innovation Norway).

A majority of firms also expressed satisfaction with the selection criteria. Only 9 per cent disagreed with the statement that the criteria are clear, whereas 63 per cent agreed, cf. Figure 7.4. However, respondents that were interviewed as well expressed that most of the criteria were intelligible, but that the main difficulties were understanding the definitions of R&D and eligible costs.

The firms' auditors seem to have a key role in the application and reporting process, acting as both adviser, when preparing and planning an application, and control mechanism, when reviewing project costs. According to interviewed RCN officials, RCN collaborates with national auditing organisations to develop guidelines and information on how to audit SkatteFUNN projects and has established workshops for firms that seek advice on how to prepare a proposal.

The greatest difference on the issue of SkatteFUNN administration was between firms that enlisted a consultant in the applying process, and those who managed the application themselves. The latter group was consistently more satisfied with the available information and guidance, as well as the proposal and reporting processes, as illustrated in Figure 7.4. We know from the interviews that consultants who assist firms in proposal preparation may also handle project reporting, thus relieving the firm of most of the project administration. Consequently, firms that enlisted consultants for proposal preparation in general get less experience with SkatteFUNN administration, and thus find it more difficult to understand. We also noted above that most of these firms had no prior R&D experience.

Figure 7.4 Firm's view on SkatteFUNN administration. N=566.



Source: Technopolis' user survey

The lower satisfaction among firms who outsourced parts (or all) of the project administration can be interpreted in several ways.

One possibility is that firms with little experience of applying for public funding are still sufficiently familiar with the requirements to find them demanding, which could explain why they choose to enlist external assistance.

Another interpretation is that firms do not examine the requirements in detail and assume that the application procedure will be cumbersome and time consuming, which also rationalises the use of consultants. Interview statements support both interpretations, and we noted above that use of consultants does not decrease with the number of SkatteFUNN projects. Either way, these firms will at best only slowly learn how to produce a proposal (interpreting requirements, transforming an idea into a proposal and a project plan etc.), making them less equipped to apply for other public grants on their own.

There seems to be few barriers for firms to use SkatteFUNN to the extent they wish. Both in interviews and free-text comments made by survey respondents, the overwhelming picture that emerges is that beneficiaries are quite satisfied with the way in which SkatteFUNN is set up and functions.

The cost ceiling was increased in 2009, 2014 and 2015, but most SkatteFUNN beneficiaries are too small to come near the cost ceiling and are in practice left unaffected by such changes.

The most important barrier raised by small firms is the delay between when the costs are incurred and when support is received, which can create liquidity problems. Another barrier mentioned is that the administrative burden is not proportional to the financial yield. Inexperienced beneficiaries of public R&D funding are in general experiencing larger administrative challenges compared to others.

Although there are some complaints about administration being too complicated or cumbersome, we have received very few suggestions on how to make SkatteFUNN more accessible or user-friendly; instead most interviewees recognise that there must be a certain level of control (which inevitably leads to administration for the user) to prevent misuse of public funds. According to interviewed RCN officials, the Council has devoted a lot of attention to lowering the limits for firms to use SkatteFUNN, primarily by streamlining the proposal process and making it more transparent and producing more unanimous decisions.

7.4 More than 70 per cent of firms rated SkatteFUNN as most easy to apply for

More than 70 per cent of firms rated SkatteFUNN as easier to apply for and as having more reasonable reporting requirements rather than other R&D co-funding opportunities, and 20 per cent believed that Innovation Norway offers an easier application process.

SkatteFUNN was preferred by 83 per cent of firms for its high rate of project approval and was considered the measure most well-adapted to firm needs and working practices (70 per cent prefer SkatteFUNN in that regard).

SkatteFUNN was also considered to offer an appropriate leverage of firms' own investment according to 53 per cent of firms, while 31 per cent prefer RCN measures and 25 per cent Innovation Norway measures in this regard. Full set of survey results on how SkatteFUNN is viewed compared to other measures can be studied in Appendix A.

7.5 Most beneficiaries write their own application

A clear majority of firms wrote the SkatteFUNN application on their own, while one third used a consultant (that did not participate in the project later). Three per cent of firms used an R&D institution that later became a partner in the project. This is in line with the results in RCN's annual user survey, which suggests that the share who use external assistance has decreased in the last three years.[105] Figure 7.5 clearly illustrates that the need for external assistance decreases with R&D maturity. In this respect there are no notable differences between firms of different size or sector.

The number of SkatteFUNN projects does not seem to reduce the need for assistance with applications, see Appendix A for detailed results. This observation suggests a path dependency, where firms that got assistance for their first application continues to do so.

Interviews with firms taking advantage of hiring consultants reveal that some of these firms get detached from most of the interaction with the SkatteFUNN administration. A possible interpretation is that the limit experienced by first-time beneficiaries is not reduced through subsequent application experiences. Only firms that have completed six or more projects are notably less likely to enlist external assistance (72 per cent, compared to an average of 63 per cent among those with fewer than six projects).

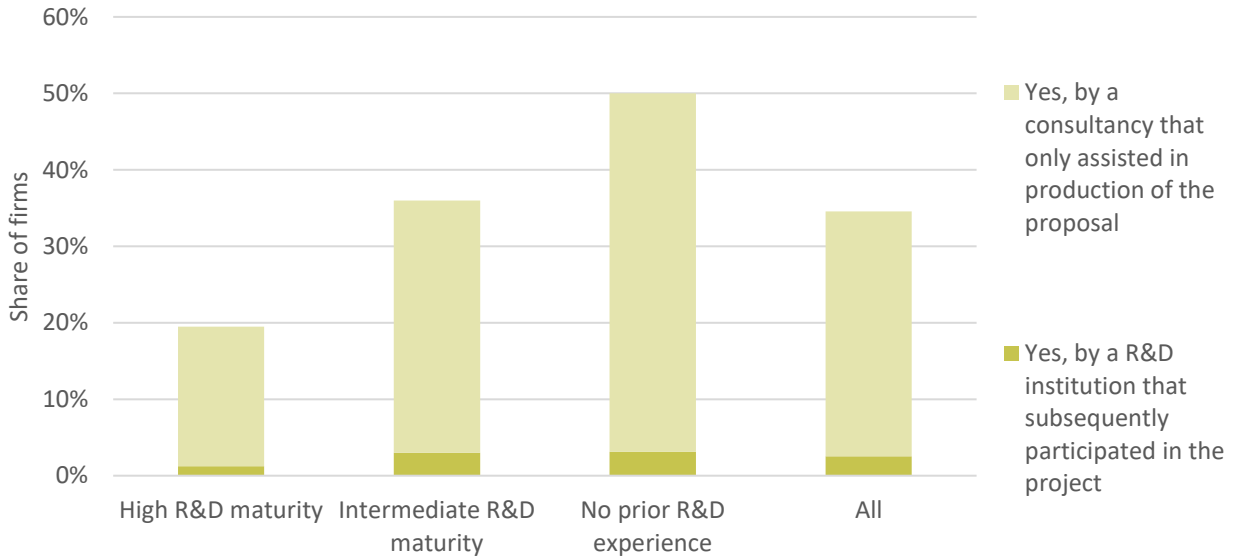
Moreover, the higher degree of R&D maturity of these firms is likely more important in this respect than the experience of many SkatteFUNN projects. From interviews we learn that most firms that have used external assistance do so because they per-

[105] "Undersøkelse om SkatteFUNN 2017", RCN, 2017.

ceive the application process as complicated, to reduce the risk of having their proposal rejected, or for convenience.

Since SkatteFUNN has size and funding-level limits, RCN measures were preferred by 44 per cent of firms, Innovation Norway measures by 39 per cent, and Horizon 2020 by 22 per cent when a project dictate a larger budget or a higher level of support.

Figure 7.5 Was the firm assisted in writing the latest SkatteFUNN proposal? N=587.



Source: Technopolis' user survey

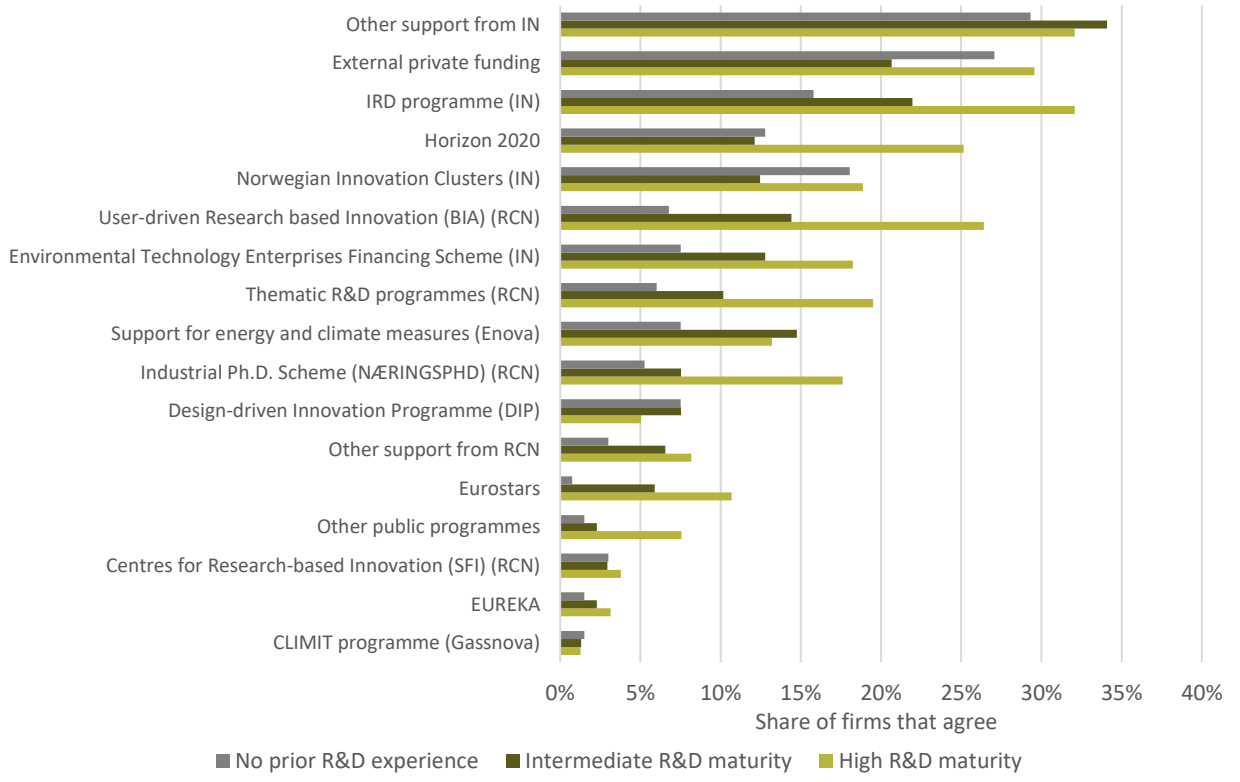
7.6 Firms accredit SkatteFUNN for its co-funding opportunities

Close to 90 per cent of firms' state that they have recommended SkatteFUNN to other firms and virtually all firms (98 per cent) rated SkatteFUNN as the most relevant co-funding measure for their current and future R&D needs. Their rating of other funding opportunities is shown in Figure 7.6.

Besides SkatteFUNN, the measure relevant to most firms was the generic "other support from Innovation Norway", despite our effort to provide respondents with a comprehensive list of frequently exploited opportunities. The third most preferred opportunity was external private funding, followed by Innovation Norway's Innovation Cluster and IRD programmes, where SMEs can apply for funding to conduct projects for product and service development in collaboration with Norwegian or foreign pilot customers or government entities.

For several measures, the difference is quite substantial between firms with no prior R&D experience and firms with intermediate or high R&D maturity. For inexperienced firms, Innovation Norway's different measures were perceived as most relevant, but these were followed (to our surprise) by Horizon 2020, rated as potentially relevant by 10 per cent. RCN's User-driven Research based Innovation programme (BIA) and its thematic R&D programmes were identified as relevant by 7 and 6 per cent of inexperienced firms, respectively.

Figure 7.6 Firm's view on other relevant R&D co-funding opportunities. Alternatives sorted by average order of descending agreement. N=564.



Source: Technopolis' user survey

Firms with high or intermediate R&D maturity held Innovation Norway's IRD programme as the third most relevant support measure. BIA, Horizon 2020, RCN's thematic R&D programmes and Industrial PhD scheme; and Innovation Norway's Environmental Technology Enterprises Financing Scheme were all rated as potentially relevant opportunities by at least 15 per cent of firms with high R&D maturity.

Centres for Research-based Innovation (SFI), EUREKA and Gassnova's CLIMIT Demo programme only attracted small shares of SkatteFUNN firms (less than 5 per cent). SFI and CLIMIT Demo mainly attract larger firms that do not use SkatteFUNN to the same extent as SMEs.

7.7 SkatteFUNN is probably more effective per krone spent, than comparable schemes

As mentioned in chapter 2.5, SkatteFUNN has considerably lower administrative costs than similar schemes. The user's assessments from our survey and interviews also indicate that SkatteFUNN has lower administrative costs than other Norwegian schemes supporting R&D or innovation in the private sector. It is therefore interesting investigate whether the relatively low administration cost is offset by higher impact from other schemes.

We have not estimated the additionality of other R&D enhancing schemes, as this was not included in our mandate. Therefore, we refer to other studies that evaluate either the impact of direct subsidies alone or together with SkatteFUNN.

Henningsen, Hægeland and Møen (2012) estimate the input additionality of R&D direct subsidies from RCN. They conclude that the input additionality of RCNs subsidies is 1.15, that is lower than the estimated input additionality of SkatteFUNN. Their estimated additionality associated with grants from ministries, Innovation Norway and other public agencies, is 0.33, which is very low. Such low level is, however, plausible as this type of support includes contract R&D, which is not primarily given with the aim to stimulate the firms' own R&D investments.

Very few studies, so far, have evaluated different policies simulteneously. Cappelen et al. (2016) evaluate various R&D supporting schemes in Norway, including SkatteFUNN and direct subsidies (grants) from RCN and IN. They find SkatteFUNN to be the most effective R&D scheme with respect to value added per million NOK in project support.[106] Furthermore, they find that both direct subsidies and tax credits have positive effects on firms' probability to apply for more patents. While direct subsidies triggered a higher number of patents among firms between 2002 and 2011,[107] SkatteFUNN was more effective given the number of triggered patents per krone spent.

Based on these few studies, we conclude that SkatteFUNN seems to be more effective both in enhancing more R&D, patents and value added per krone spent.

[106] . More details on this specific part of evaluation can be found in Nilsen et al. (2018).

[107] We have also observed higher patent intensity among firms with support from RCN compared to SkatteFUNN and IN are in line with in Chapter 6.1.

8 Compliance and risk of misuse

We have analysed misuse of SkatteFUNN based on selected indicators and randomized audits in collaboration with the Norwegian Tax Administration. The analysis confirms that misuse of SkatteFUNN does occur. For about 10 per cent of the audited firms it was revealed discrepancies between hours reported to the government and in their SkatteFUNN-claim. About 13 per cent of the firms reported ordinary costs as R&D investment.

Based on the characteristics of the audited Skattefunn beneficiaries, we have estimated the upper bound for misuse related to reporting ordinary operating costs as R&D investment. Adjusting for misuse, SkatteFUNN's estimated impact is reduced. However, one krone in forgone tax revenue does on average increase R&D investments by more than one krone even if we assume misuse is at the upper bound.

We present several suggestions of measures that could limit and prevent misuse, including more controls and sanctions.

A continuing concern related to R&D tax incentives is the possibility for tax evasion, tax avoidance and wrongful cash payments. SkatteFUNN is a rights-based tax credit scheme, hence there is no overall aggregate ceiling for the scope of forgone tax revenue for the state, nor is there any competition between firms ensuring that the funds are awarded to the best R&D projects.

Tax evasion and other misuse of public schemes will always be a loss to society and tax payers. In addition to the societal costs of forgone tax revenue and wrongful publicly financed cash payments, misuse of SkatteFUNN may result in a loss of legitimacy of the scheme.

In the case of SkatteFUNN misuse typically involve reporting accrued costs related to ordinary operations as R&D costs or inflating R&D costs. Both actions will result in a larger project cost as a basis to receive SkatteFUNN.

Although some misuse takes place, little is known about the scope and forms of misuse. If misuse results in a much higher registered level of R&D than what is actually taking place, our evaluation will be at risk of overestimating the additional R&D investment caused by SkatteFUNN, potentially hampering the evaluation. Furthermore, misuse could also contribute to underestimate the return on R&D investment. The main purpose of this chapter is to check the robustness of our findings with respect to the possible misuse of the scheme.

In the following we go through the inherent trade-off between being a general scheme with low administrative costs and preventing misuse, the different forms of misuse and failures of compliance, approaches to control misuse and indicators of misuse. Furthermore, we present the results from stratified randomized controls completed by the Norwegian Tax Administration and illustrate to which degree misuse might impact our estimates for input additionality negatively. Finally, we suggest ways of ensuring compliance.

8.1 Trade-off between low administrative costs and prevention of misuse

We are aware that misuse of SkatteFUNN is taking place. However, one must expect that broad public schemes aiming to embrace many firms, will be illegally exploited to a larger extent than more specific schemes geared towards a few specific firms. This is especially true if you want to keep administrative costs and control routines at a low level, which has been the case with SkatteFUNN.

Finding the right balance between user-friendliness and low administrative costs for firms and government on the one hand, and the prevention of fraud and misuse on the other is no trivial challenge. According to Uhlíř, Straathof and Hambro (2017) tax incentives across the world have generally been expanding, both because more firms use them and because they have become more generous. Meanwhile, the governmental administrative resources have generally remained the same. This is definitely the case for SkatteFUNN, that has relatively low administrative costs because it is easy to administer, and the control activity is limited.

To land a reasonable trade-off between the cost of using more resources on application processing and control and the cost of supporting firms misusing the scheme, the extent of misuse must be assessed. For the legitimacy and impact of the scheme it is important that the misuse is kept at a minimum.

8.2 Different forms of misuse

As the tax incentives vary from one country to another, the prioritisation of which elements in an application or scheme should be addressed for preventive purposes or control, must be looked at in a national context.

When establishing preventive measures or controlling applications or claims it is useful to take into consideration how misuse may take place, and which of the possibilities of misuse should be given most attention.

In our context, misuse of the scheme is defined as:

Activities conducted by a firm to access public funding through SkatteFUNN, which is not related to R&D efforts. These activities may include situations where firms unjustified claims SkatteFUNN or fails to provide full disclosure. Failure of compliance can either be conscious or by negligence.[108]

The definition above implies that misuse is defined broadly. Misuse include partly or completely fictive projects aiming at access to unjustified tax deduction. Misuse also include inflating R&D costs by including non-R&D costs (i.e. claiming tax deduction for ordinary operating costs) or other failure to comply due to negligence or lack of knowledge.

The lack of transparent accounts set up according to the rules of SkatteFUNN, or the lack of an approval from a tax auditor who has scrutinized the project accounts correctly, is not in itself misuse of SkatteFUNN. However, disrespecting the formal rules that apply is an indicator of misuse.

In our further investigations of possible misuse of SkatteFUNN, we start by presenting potential ways of misusing the scheme, within the context of how SkatteFUNN is administered. Through dialog with The Norwegian Tax Administration, we have concluded that the following probably are the most common forms of misuse:

- Inflating the costs of the R&D project
- Presenting something as R&D which is not, or is only in part R&D

Claiming a tax deduction or a cash payment related to equipment that may not be necessary for the performance of the R&D project is an example of presenting cost outlays for other purposes as eligible. Inflating the costs can for example be done by

[108] With this definition misuse does not include the situation where a tax deduction is rejected on a formal basis (e.g. due to lack of auditor's attestation) or due to misinterpretation of the regulations (e.g., claims made by an institution that is not taxable).

claiming for more hours of manpower or machine time than has been used for the R&D project.

Furthermore, a relatively common issue, relevant in the case of SkatteFUNN, is exaggerated internal pricing (for work performed, equipment leased, or the use of intellectual property used) within a corporate group to minimize the total tax burden. In the case of R&D this would benefit the firm through inflating the cost base for claiming the tax credit.

The scheme could also be misused by falsely presenting a project as R&D, when the project does not meet the R&D definition set in the SkatteFUNN-regulation. This could for example be the case where the R&D is carried out for the benefit of another firm in the corporate group or when the R&D is not carried out at all.[109]

We believe that the Research Council of Norway's (RCN's), the Norwegian Tax Administration's and auditors' reported lack of opportunity to know whether the information given in the application is correct or not, is significant for potential misuse.

We will focus on misuse related to inflating R&D costs or presenting costs falsely as R&D main categories of misuse. There are, however, several other possibilities for misusing the scheme. For example, not reporting direct grants that could, depending on the circumstances, lead to a reduction in the tax credit, or by neglecting to deduct the sale of a prototype from the eligible costs.[110]

8.3 Control approaches

Different countries have different approaches for hindering misuse of their R&D tax incentives. The approaches can broadly be divided into 1) those related to evaluating the applications for tax credit and 2) those related to controlling the compliance of firms whose application is accepted. We will go through both below.

8.3.1 Control of the applications

In SkatteFUNN, all the R&D projects are assessed on an ex-ante basis in relation to the question of R&D content and which activities may be regarded as part of the R&D project. Ex-ante decisions give firms more certainty and predictability than ex-post decisions. A compulsory ex-ante review implies that whether the R&D requirement is fulfilled, is checked for all project applications. This characteristic is important for the potential to misuse the scheme, as it makes it difficult to claim tax deductions for costs related to activities that are not presented in the project plan.

This is not the case for similar schemes in all countries. In Portugal, for example all R&D projects are checked ex-post for compliance with the R&D definition and the Tax Administration receives a confirmation of the total eligible cost or a proposal for correcting the claim from ANI (National Innovation Agency). Ex-post rulings are based on what has taken place, and not what was planned. Therefore, ex-post evaluation of applications might be less burdensome from an administrative point of view, both for the firm and for the public authorities (Uhlíř, Straathof, & Hambro, 2017). However, the issue of whether the content of the application is correct still applies.

Applying a given R&D definition ex-ante or ex-post is in theory the same, assessing whether the facts meet the elements in the definition. In practice, the relationship between industry and tax authorities could differ in the two situations. In ex-ante schemes, a dialogue can take place with adjustments to the R&D project and the wording used to

[109] The R&D-definition requires that the firm intends to use the R&D results in its own activities. Contract research falls outside the R&D definition

[110] SkatteFUNN can be combined with direct grants, if the amount of aid does not exceed the permitted level of support under the EU Tax Exemption Regulation 651/2014.

explain the project. If approval is not given, the firm can choose not to run the project. In the ex-post schemes, the firm has already spent its money and the issue of approval is critical to the question of how much of the costs the firm must pay itself. This might induce the tax authorities to be lenient when applying the R&D definition or result in conflicts that lead to appeals.

In Canada, that uses more resources than most countries in guiding firms to claim the tax credit correctly and evaluate compliance, approximately CAD 400 million is reclaimed annually as non-compliant expenditures (Uhlíř, Straathof, & Hambro, 2017). Canada assess each firm's technical and financial eligibility. Canadian authorities invest in both detecting and deterring non-compliance. These activities and controls successfully identify and protect important amounts of tax credits each year.

8.3.2 Control of compliance

The objective of controlling beneficiaries of SkatteFUNN is threefold. Firstly, the control aims at providing knowledge about the forms of misuse that can occur, which can be utilised to alter formal characteristics related to the scheme. Secondly, the control aims at recuperating funds that should not have been provided to the firms misusing the scheme. Thirdly, while the presence of controls does not provide guaranteed protection against misuse, it can help to both mitigate losses and deter some potential fraudsters by enhancing the perception of detection. Hence, controlling beneficiaries of SkatteFUNN aims at ensuring the scheme's legitimacy by deterring further misuse.

Controlling beneficiaries' compliance could be based on risk assessment or random selection. For the Tax Administration it is typically most relevant, due to cost efficiency, to select a risk-based approach. For statistical purposes however, such an approach would not give results representative for all firms, but rather reveal more misuse than what generally is taking place. Random tests are therefore more useful to quantify the level of misuse.

A risk assessment could consist of several elements that either alone, or in combination with other factors, exceed a certain limit of risk judged as critical. The forms of misuse that is most widespread or imply the highest risk of economic losses for the state depend on several factors, such as firm size, group relationship, ownership and industry.

In the UK, a risk-based assessment system is established. This system takes into consideration several features that typically affect tax claims and that have been associated with high-risk of misuse. This includes for example criteria based on project size and changes in claim characteristics. The system utilizes profiling techniques to select high-risk claims for further investigation. An example highlighted by HM Revenue and Customs (2017) are the claims of tax credit for costs related to external R&D personnel.

Canada also uses a computerized risk-assessment system for initial screening of claims to ensure that the claims at highest risk for non-compliance are detected and subject to the verification activities (Uhlíř, Straathof, & Hambro, 2017).

Although controls based on random selection is useful in estimating the scope of misuse, this approach is rarely used in practice. One exemption is France, where a sample of firms is audited each year (between 7 and 8 per cent). The result of this control activity has been a recuperation of about 280 million euro (Uhlíř, Straathof, & Hambro, 2017), implying that their control activity is self-financing.

There has not been a consistent strategy for audits of SkatteFUNN beneficiaries. The beneficiaries are,

however, partly audited when applying for SkatteFUNN. The application must specify cost types and be certified by an auditor. In addition, the firm is obliged to have separate project accounts including hours worked on the project per employee and the hourly cost for each employee. These accounts are to be kept on a continuous basis. A prudent auditor would also require all employees working on the project to confirm their project engagement.

A significant issue for The Norwegian Tax Administration when auditing SkatteFUNN beneficiaries has been a lack of resources in assessing whether the activities in the project are in line with the description sent to RCN. The Norwegian Tax Administration lack the competence to assess whether the actions classify as R&D in accordance with the regulations. Furthermore, it is difficult to assess whether the discrepancies found during audits are related to deliberate misuse or sloppiness. The Norwegian Tax Administration is concerned that there is an established culture in which one does not have sufficient respect for the regulatory requirements. For instance, there has been a common problem with tax deduction claims lacking the auditors signature.

To improve the efficiency of the audits, RCN and the Norwegian Tax Administration entered into an agreement in 2016. The objective is to enhance collaboration between the two, making it easier to reveal and sanction misuse.

In 2018, the Norwegian Tax Administration has conducted a randomized audit of SkatteFUNN beneficiaries to increase the knowledge of unintended adaptations and misuse of the scheme. The results of these audits are presented in chapter 8.5.

8.4 Empirical indicators of misuse

Finding suitable indicators of misuse is challenging for several reasons. For example, one might think that comparing firms' claimed R&D costs in the application, with those reported in their financial statements, could be an indicator. If the claimed R&D costs were to exceed the costs of R&D in the firm´s accounts, this could be an indication of misuse. However, there is no requirement to specify R&D in financial statements.[111] Notes on R&D costs are to be included in the statements of large firms, while most SkatteFUNN firms are small.[112] Hence, such an approach would fail to include relevant parts of the population of firms. In addition, a mismatch between financial statements and SkatteFUNN applications need not be evidence of misuse. It may reflect a failure to fulfil the requirement for presenting notes in the accounts.

Another option is to compare SkatteFUNN statistics with R&D statistics. If a firm claims to have had higher R&D costs when applying for SkatteFUNN than what it has reported in the R&D statistics, this could be an indication of misuse. However, this is also a weak indicator. The main reason why this comparison is not a useful indicator is that the definition of R&D is much broader in SkatteFUNN, than in the R&D statistics (since 2011). Secondly, the firms included in the R&D statistics rarely have less than 10 employees, whereas most of the firms claiming SkatteFUNN are smaller. Thus, the R&D statistics would not cast any light on possible misuse by the smallest firms.

Below we will go through some suggested empirical indicators of misuse.

[111] See chapter § 7-14 of the Accounting Act.

[112] Small firms are defined as having less than 50 employees, less than NOK 70 million in revenue and balance of less than NOK 35 million.

8.4.1 The potential for misuse increases with generosity

Figure 8.1 illustrates that an increasing share of firms have got more in tax deduction. When the scheme was first implemented, almost 80 per cent of the beneficiaries claimed tax credit below the ceiling for internally produced R&D, of NOK 4 million. R&D costs of NOK 4 million gave a tax credit of NOK 720,000 or NOK 800,000, depending on whether the firm was large or SME, respectively.

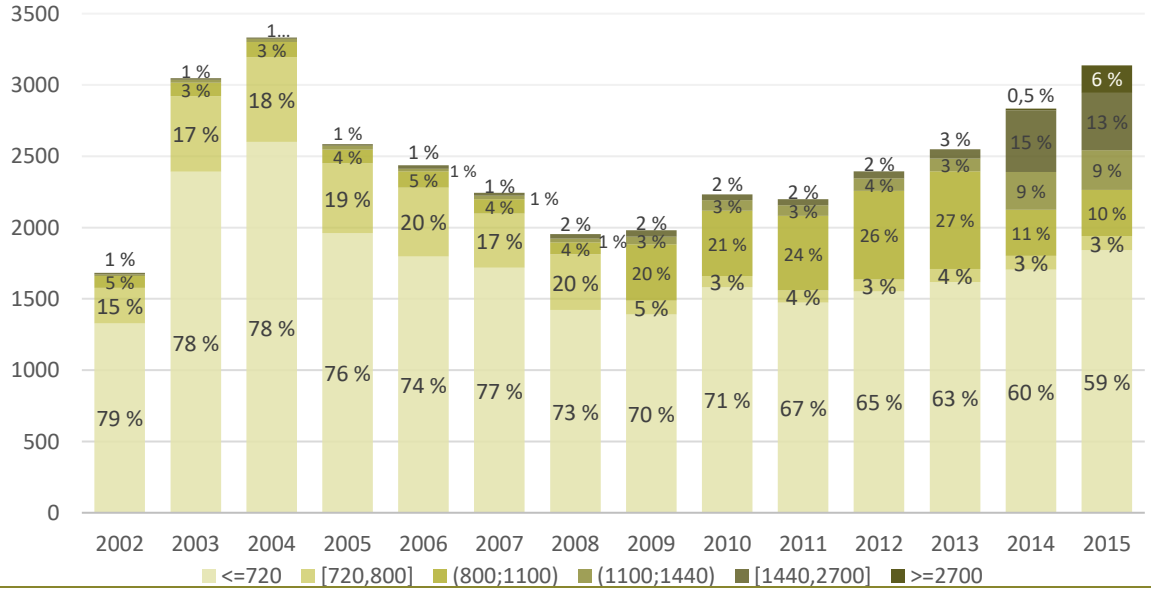
In 2015, the share claiming less than NOK 720,000 in tax credit was reduced to about 60 per cent of the beneficiaries. The share claiming more than NOK 1.4 million increased sharply in 2014 and the share claiming more than NOK 2.7 million increased in 2015 (the latter implying R&D expenses of more than NOK 15 million). These increases follow the increased cap in the corresponding years. Measured in the scope of tax credit, firms claiming more than NOK 2.7 million accounts for about 25 per cent of the forgone tax revenue due to the scheme in 2015.

Firms claiming more than NOK 1.4 million accounts for almost 50 per cent of the forgone tax revenue.

With an increase in the scheme's generosity through raising the cost ceiling significantly, without a corresponding increase in audits, the temptation to misuse SkatteFUNN may have grown. However, an increased ceiling will also make the scheme more attractive for larger firms (with larger projects), where the risk of misuse probably is smaller as large firms often have better developed system for auditing, relative to smaller firms.

Several forms of misuse are more difficult in larger firms than in smaller ones, as more people are typically involved in the decision-making process, and auditors generally would pay more attention in larger firms than in smaller ones. At the same time, we observe a range of small firms with very large projects, increasing the potential of misuse also for SMEs. In any case, a consistent strategy for audit is required to diminish the temptation to misuse SkatteFUNN.

Figure 8.1 The number and share of firms by size of tax credit (in thousand NOK)



Source: Statistics Norway and Samfunnsøkonomisk analyse AS

8.4.2 Beneficiaries of the largest projects are often not tax liable

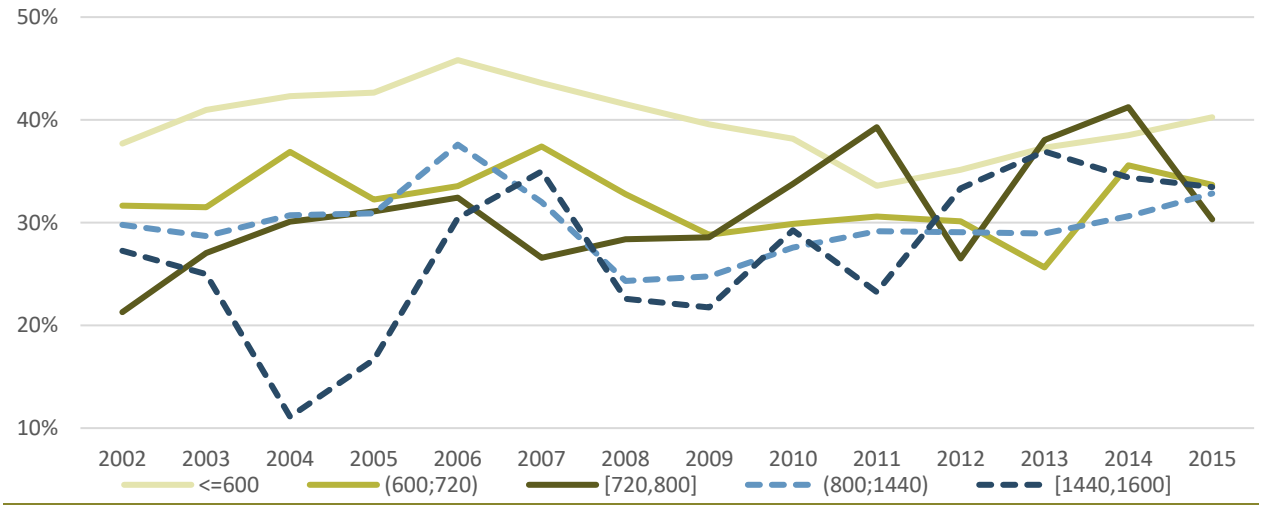
When looking closer at the beneficiaries of SkatteFUNN we find that there is a strong positive correlation between claiming tax credit for larger projects and not being (fully) tax liable for the year of the claim.[113] Figure 8.2 illustrates that the group of firms with the highest tax credit (above NOK 1.44 million), represented by the blue dotted lines, also have the lowest share of tax liable firms for most years. In total, only 34 per cent of the firms were fully tax liable in 2015.

It could be a reason for concern that firms that are not (fully) tax liable, on average, have more R&D expenses than other firms. Although, firms in the start-up face are likely to experience losses and utilise schemes like SkatteFUNN, it is surprising that they have the largest R&D projects.

In addition to granting tax deductions for R&D costs, SkatteFUNN also offers cash payments equivalent to the tax credit to firms that are not tax liable. About 70 per cent of the total forgone tax revenue and payments made due to SkatteFUNN was given to firms as cash payment in 2016. This amounts to about NOK 3.5 billion.

The option of receiving cash instead of a tax deduction is identified as a factor that might increase the likelihood of misuse (Økokrim, 2015). Figure 8.3 illustrates that the share of tax deductions paid out in cash, on average, is higher for the group of firms with larger claims. This could be an indication of misuse, as it is possible for firms to establish themselves with a sole objective of getting cash from SkatteFUNN without the intention of performing R&D. It is not easy to assess the scope of such fraud. However, it should to a large degree be prevented if the auditor does his job. However, this would not be the case if the auditor participates in the scam, is not able to judge the accounts correctly, or if a substantial share of claims is accepted by the Tax Administration even without an auditor signature.

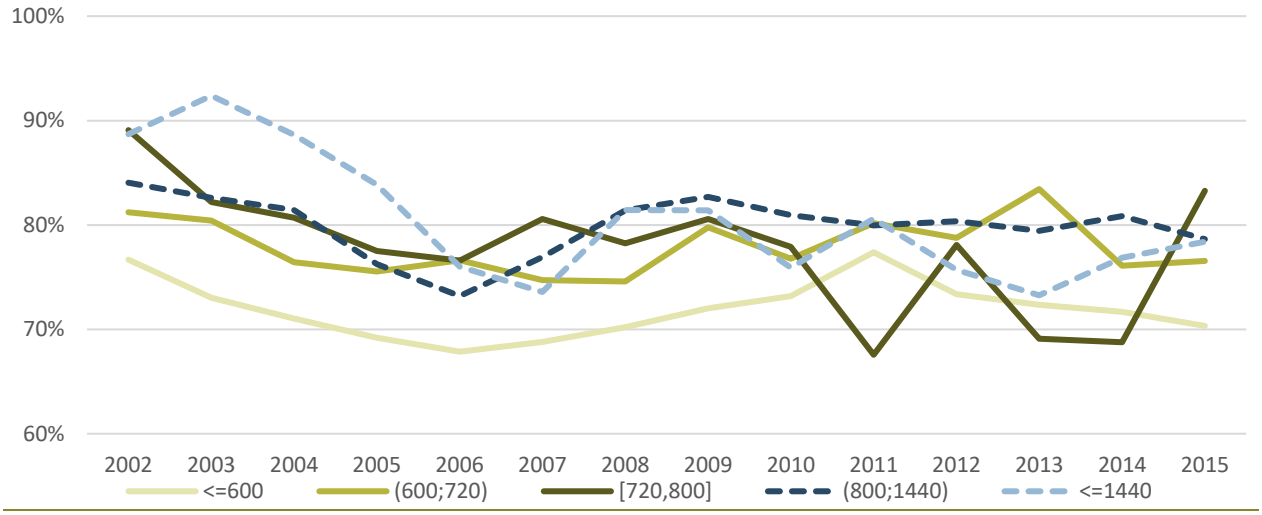
Figure 8.2 The share of tax liable firms by tax credit size (NOK 1000)



Source: Statistics Norway and Samfunnsøkonomisk analyse AS

[113] Firms that are not tax liable during a year are firms that are not in tax position, i.e. firms undertaking a loss or firms with a smaller profit than the tax deduction they get from SkatteFUNN. To receive SkatteFUNN it is a requirement that the firm is taxable in Norway. However, it is not a requirement that the firm is in a tax position i.e. that their tax liability is zero.

Figure 8.3 Share of tax deductions paid out as grants by tax credit size (NOK 1000)



Source: Statistics Norway and Samfunnsøkonomisk analyse AS

8.4.3 High R&D costs, but low wage costs?

Overall, we find that the firms getting the tax deduction in cash are slightly smaller, both measured in employees and revenue, than those who get a deduction on their tax expenses. This is as expected, as tax liable firms would have a running production creating income and would therefore usually be larger than start-ups.

When analysing the relationship between tax credit, employees, salaries and R&D costs, we find that for smaller firms the tax deduction, which is often paid out as cash, relative to total wage costs is much higher than for larger firms. This relationship is particularly strong for firms with one employee. The average tax credit in such firms covered about 70 per cent of the firms' average salary expenses. When comparing to firms with more than 50 employees the average tax credit covers 0,6 per cent of the average salary expenses.

In the previous evaluation Fjærli (2007) compared timesheets from project accounts with what firms report in the R&D surveys conducted by Statistics Norway. He found that time recorded per employee in the timesheets is 50 to 100 per cent higher than expected based on the firms' characteristics. This was an indication that the time spent on R&D projects was overestimated in the project accounts. However, the lack of correspondence between the project accounts and the R&D survey could also be due to underreporting of R&D for statistical purposes.

Fjærli (2007) finds that some firms had very high tax deductions, high budgeted R&D costs per employee, and unreasonably high personnel costs in relation to the firm's actual salary costs. These numbers were driven by the five to ten per cent of the firms with the most extreme observations. The firms are generally small, typically having less than 10 employees.

Among firms with only one employee, Fjærli (2007) find examples where the tax deduction and the budgeted R&D costs were very high compared to the firm's salary payments. This may indicate misuse through inflated hours, or that the hourly rate of pay used does not correspond with the actual salary. The salary paid was also in some cases very high, despite a low operating profit. Furthermore,

Fjærli (2007) found that the salary appeared lower in similar firms with no R&D tax credit.

The findings from Fjærli (2007) was part of what led to the implementation of a cap on the hourly wages and number of hours per year. These findings are therefore interesting as a background of why the caps where implemented. We have no reason to believe these findings are not relevant today, although the implementation of a maximum hourly wage and hours spent likely have reduced this issue significantly.[114]

It is however, important to note that SMEs often lack the skills and equipment themselves to carry out their R&D, and must therefore, to a greater degree than larger firms, purchase external resources. Hence, it is to be expected that SMEs' R&D expenses per employee or as a share of wages are higher, than for larger firms. Still, it is reasonable to assume that misuse is easier in SMEs. When there are few employees, or only one owner, there will be a more direct personal interest in the economy of the firm. It is also more risk associated with misuse in larger firms, because dealing with illegal activities that employees can observe is risky.

When it comes to larger firms, however, it is difficult to analyse the relationship between wages and tax deduction, as we do not know how large part of the firm is devoted to the SkatteFUNN-project.

Therefore, we concentrate on firms with only one employee here. When we limit the sample to the firms with the 10 per cent highest estimated R&D personnel costs (the project's total cost of R&D personnel), we find that they are several times higher than the wage costs of the firm, cf. Figure 8.4.[115] When a firm has higher R&D personnel costs than the actual wage costs it can imply that they purchase R&D services for example from other firms in the same corporate group, collaborate with other firms or that they inflate their own R&D personnel costs.[116] The Norwegian Tax Administration does find in their survey that firms that are active in one or several collaborative projects do sometimes exceed the maximum ceiling for R&D costs.

When purchasing R&D services from others one is not subject to the ceiling for hourly costs and hours spent. This can create an incentive to establish subsidiaries, or purchase R&D services from other firms in the group, to circumvent the cap on the number of hours permitted and the cap on hour costs. It is uncertain to which degree this takes place merely to artificially avoid the restriction in SkatteFUNN.

Figure 8.4 The median ratio between R&D personnel costs and total wage costs for firms with one employee (left) and the number of firms (right)

Source: Statistics Norway and Samfunnsøkonomisk analyse AS

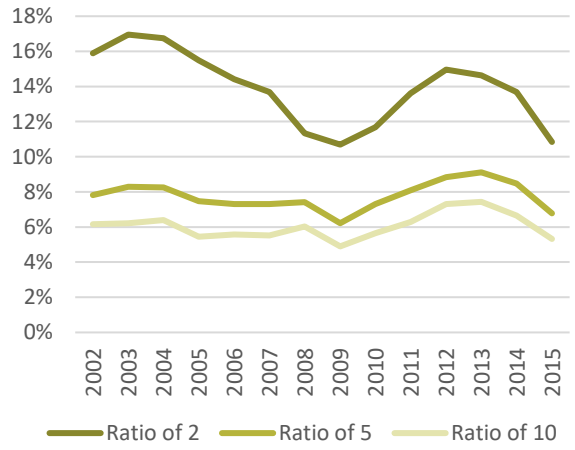
[114] It should be noted that during the first years of SkatteFUNN, many believed that unpaid salaries could be included in the cost base of SkatteFUNN, which could cause accounts showing lower wage costs than presented in the claim. At the time, some obvious cases of misuse were detected along another line, where the owner of the firm presented R&D costs based on an unrealistically high number of R&D hours, and at a very high rate. This led to a cap on the number of eligible R&D hours per employee and a cap on the wage cost.

[115] The estimated R&D personnel costs are collected from RCN database on SkatteFUNN applications. We find that on average, the actual R&D costs end up being slightly less than 8 per cent of the estimated R&D costs, on average.

[116] When R&D is purchased from firms that are not approved by RCN as research institutions the ceiling for R&D expenses is the same as if a firm would perform the R&D itself. See section 16-40 second paragraph letter b.

When restricting the sample to firms that have not reported formally to RCN that they collaborate with other firms, we find that the there is still about 14 per cent of the firms benefitting from SkatteFUNN, each year, that have a ratio where the R&D personnel costs are more than twice as high as the reported wage expenses for the firm, cf. Figure 8.5. However, the estimated R&D personnel costs typically accounts for the whole project period, which on average is 2,5 years. Taking this into account, we look at a ratio of more than five instead and find that the share of SkatteFUNN beneficiaries with R&D personnel costs at more than five times the firms wage costs is on average eight per cent for the whole period, cf. Figure 8.5. Furthermore, 90 per cent of these firms have less than three employees. When restricting the sample to firms with estimated R&D personnel costs of more than ten times their average wage costs the share is on average 6 per cent of SkatteFUNN beneficiaries. We do not find a logical explanation for such high R&D personnel costs, and therefore argue that this could be an indication of misuse.

Figure 8.5 The share of beneficiaries by the ratio of R&D personnel costs and total wage costs



Source: Statistics Norway and Samfunnsøkonomisk analyse AS

Fjærli (2007) analysed potential misuse of SkatteFUNN by going through project claims. He found that only about half the claims where of sufficient quality. Furthermore, most auditors noted that they found it rather complicated to verify whether the values recorded by firms were true. Sometimes auditors view it as impossible.

8.4.4 Group structure can be utilised to bypass ceilings

The Norwegian Tax Administration do find that there has been an adjustment in firm behaviour due to the NOK 600 per hour ceiling. Hours are increasingly bought from other firms in a corporate group, indicating a tactical adaptation. There is a significant continuous increase in R&D expenses purchased from other countries. Økokrim (2015) also expresses concerns related to this increase.[117] Purchasing R&D related goods and services from abroad is not forbidden in any way. However, it does increase the possibility of misuse because it is difficult for the tax authorities to audit that the declared costs indeed are eligible.

8.4.5 Challenging to audit foreign firms

For the cases that have been addressed by the Norwegian Tax Administration, it seems like some corporate groups utilise designated "single purpose" firms to perform the R&D. The question of whether the R&D is of benefit to the firm is often difficult to answer (§ 16-40-2 (1)). In some of these cases, the group's head office is abroad, and the R&D is purchased from the foreign firm. Another example are cases were the firm uses employees abroad, usually in countries outside the EU.

When the R&D is conducted in other countries, it becomes more difficult and costly to audit the projects. In particular, determining whether claimed

[117] ØKOKRIM is the Norwegian National Authority for Investigation and Prosecution of Economic and Environmental Crime.

costs are in fact eligible. Furthermore, purchasing R&D from foreign firms can be used to bypass the rules of hourly wage. This is also possible when purchasing R&D services form other Norwegian firms, for example in the same corporate group.

The Norwegian Tax Administration argues that the reason for the increase in purchasing R&D from foreign firms is the increased ceilings. Due to the increased ceilings firms will have an incentive to increase their R&D costs. Purchasing R&D services from other countries is a way to do that.

8.5 Stratified randomized audits of beneficiaries

Estimating the scope of misuse is very difficult, both methodological and when it comes to obtaining relevant data. Without access to sufficient audit-data, it is not possible to assess with certainty to which degree misuse occurs. We have therefore chosen to address this problem by analysing various factors, including audit results, to provide an indication of the scope of misuse.

This chapter describes empirical indicators of misuse, including microdata and audit data characteristics. The strategy and results for recent audits conducted by the Norwegian Tax Administration will be presented.

Our main source of information about misuse stems from the Norwegian Tax Administration's audit of 200 beneficiaries during the spring of 2018.

In the audit, SkatteFUNN beneficiaries were separated into two mutually exclusive groups defined as high- and low-risk firms. Then firms have been chosen randomly for the audit within each group. This method is called stratified randomization and, in short, can be described as a compromise between pure randomization and risk-based audit (cf. chapter 8.2.2).

On the one hand, ensuring representation of high-risk firms guarantee that we gather sufficient information to confirm or reject the assumed indicators of misuse. Stratification can also increase the accuracy of future audits. Identifying characteristics of misusing firms can enhance cost efficiency for audits, as well as having a preventive effect.

On the other hand, a randomized stratification ensures that firms defined as having low risk of misuse are also represented in the audits. Also, auditing low risk firms ensures that the controls will be useful for a general analysis of misuse, including estimates of scope.

Based on analysis of empirical indicators and experience from previous audits, five criteria defining a high-risk beneficiary were selected. The firms were characterised as high-risk if two or more of the five criteria were satisfied.[118] Of 4,149 beneficiaries of SkatteFUNN in 2016, 1,354 firms were characterised as high-risk and 2,815 as low-risk.

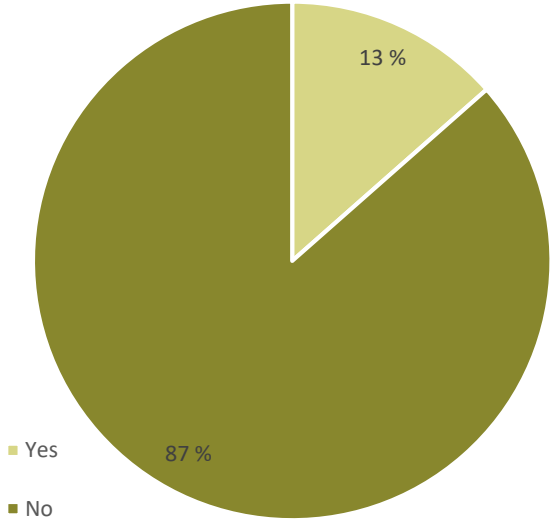
200 firms were audited.[119] Of these 200, 75 per cent were randomly chosen from a group categorized as high-risk firms and 25 per cent from a group categorized as low-risk firms. Further we describe the main results of the audits.

A relatively large share of the firms seemingly reports ordinary operating costs as costs related to R&D.[120] In 13 per cent of the firms, the Norwegian Tax Administrations' investigator considered this to be the case, see Figure 8.6. When separating the firms into low and high-risk the audits found that 14

[118] To ensure the quality of future audits, the exact risk criteria will not be publicly available.
[119] Having an active project in 2016, firms claimed tax credit in 2017, while the audit were conducted at the start of 2018. Not all topics in the audit was relevant for all of the 200 audited firms, hence the number of firms vary between questions (see N= in the figures).
[120] Ordinary operating costs are expenses firms incurs through its normal business operations, including rent, equipment, inventory costs and marketing. Payroll expenses is not included in the definition we are using.

per cent of the firms in the high-risk group had reported fictive R&D costs, compared to 11 per cent in the low-risk group. In addition to the 13 per cent, the investigator is uncertain of whether ordinary operating costs have been reported as R&D in another 9 per cent of firms. Another 12,5 per cent of firms were found to include long term assets in their SkatteFUNN claim.

Figure 8.6 Share of respondents that have reported ordinary operating costs as R&D costs. N=200

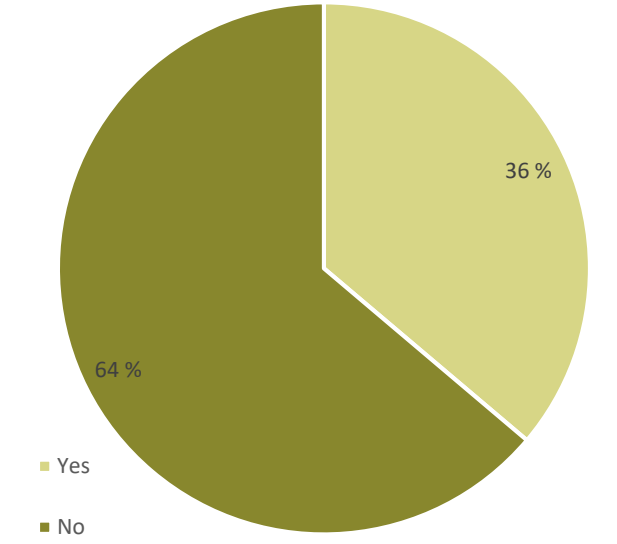


Source: The Norwegian Tax Administration

Close to 40 per cent of the audited firms reported purchasing R&D from approved R&D institutions. 36 per cent of firms purchased R&D from foreign firms, cf. figure 8.7. Of the high-risk firm's 42 per cent did purchase R&D from foreign firms, whereas for the low risk group only 18 per cent did.

Purchasing R&D from foreign firms is not misuse of SkatteFUNN. However, it creates a challenge for the auditors. When the R&D is conducted in other countries auditing the projects will be costlier. Purchasing R&D from foreign firms could therefore be used to for example bypass the rules of hourly wage.

Figure 8.7 Share of firms that had purchased R&D from foreign firms. N=200



Source: The Norwegian Tax Administration

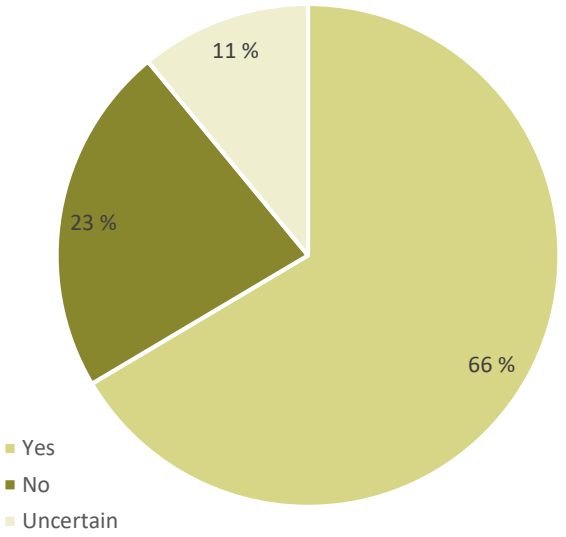
Auditing the hours spent on SkatteFUNN-projects was also an important part of the audits. There are relatively large deviations of the hours in the firms registered time sheets and hours in RF-1053.

The hours reported in RF-1053 can exceed actual hours spent on the project in case of writing hours for persons who are not involved in the project, persons who are on sick-leave or on vacation, or persons who do not work in the firm. However, failure by a project co-worker to register his/her working hours for the project by negligence can also result in such deviations.

Figure 8.8 illustrates the audited firms by whether their registered time sheets corresponds fully, partly or not with their reported hours in RF-1053.[121] For a large share of the firms' correspondence is uncertain. The extent of correspondence does not vary significantly between the firms in the two risk groups.

[121] Note that only for 176 of 200 controlled firms this check was relevant.

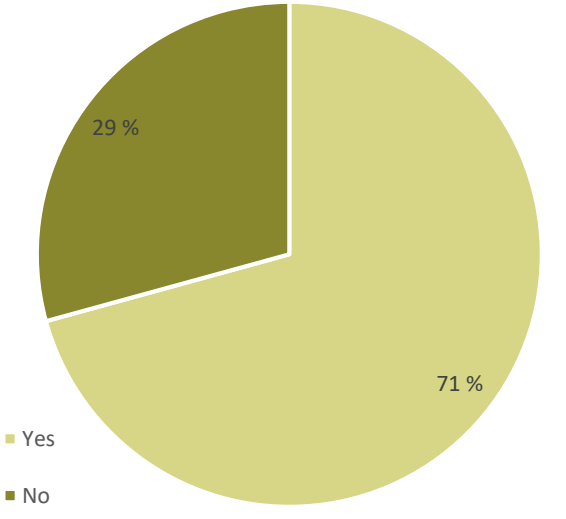
Figure 8.8 Audited firms by whether their registered time sheets corresponds or not with their reported hours in RF-1095, or whether the correspondence is uncertain. N=173



Source: The Norwegian Tax Administration

In addition to lack of correspondence in hours reported, almost 30 per cent of firms lack signature by employee and project leader on their time sheets, cf. figure 8.9.

Figure 8.9 Share of firms were the hours are signed by employee and project leader. N=164



Source: The Norwegian Tax Administration

Of the 200 audited firms, 7 per cent are subject to an extended audit due to uncertainties and suspicion of misuse. When separating the beneficiaries into groups of high and low risk, 7,5 per cent of beneficiaries defined as high-risk, and 4,5 defined as low-risk would be subject to extended audit. The main reasons for the extended audit are related to uncertainty in the reporting of project costs, uncertainty regarding involvement in foreign firms (typically foreign ownership or purchase of R&D) and lack of information about the firm's account's or mistakes related to reported project hours.

The Norwegian Tax Administration conclude that the most common forms of misuse discovered is inflating the project's costs, typically by inflating hours or including ordinary costs as eligible expenses related to the R&D project.

8.6 The impact of misuse on input additionality

If misuse is extensive, it will distort our estimates of input additionality, cf. chapter 4. The input additionality is estimated as SkatteFUNN's impact on firm's investment in R&D. Investment in R&D are measured as their R&D costs.

In chapter 4, we use estimate the input additionality using the term Bang for the Buck (BFTB). BFTB measures how much additional R&D has been induced per krone spent on the scheme (including forgone tax revenue).

To test the robustness of our results for input additionality with respect to misuse we adjust the firm's R&D expenses used in chapter 4 for possible misreporting. For that purpose, we utilise the information from The Norwegian Tax Administration's audits about firms reporting regular operating costs as costs related to R&D.

First, we use the risk criteria from the audits to divide the *whole* population of SkatteFUNN firms into mutually exclusive groups of high and low risk for the period between 2008 and 2015.[122]

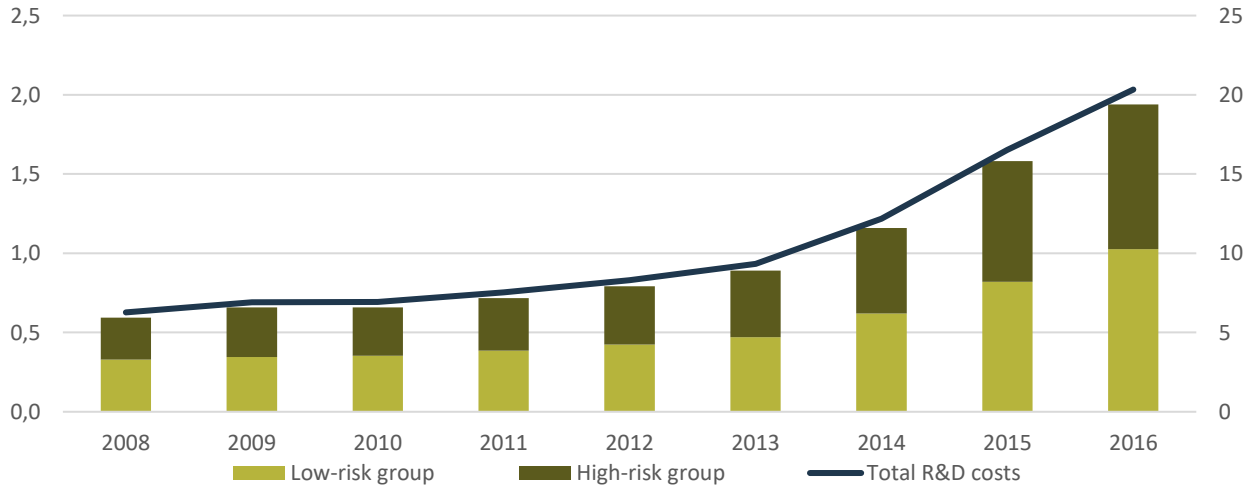
Second, we take into account that different groups of firms can have different project sizes, and that this would also affect the scope of misuse.[123] Hence, we weigh the share of audited firms that reported ordinary operating costs as R&D costs by their project expenses. As a result, we find that up to 11.2 per cent of R&D expenses could be misreported in 2016 by firms in the high-risk group and 8.4 per cent by firms in the low-risk group.

We do not know, however, how much of the ordinary operating costs that are misreported as R&D costs.[124] Therefore, we assume the extreme scenario of all costs reported as related to SkatteFUNN project are false R&D. These costs include both costs related to personnel and equipment costs.

Finally, we calculate the sum of R&D expenses for each group. While the share of high-risk firms vary between 2009 and 2016, the shares of R&D expenses accumulated within each group are quite stable (equal to about 40 per cent for high-risk group and about 60 per cent for low-risk group).[125] Based on the assumption that the share of audited firms failing to comply with the scheme's requirements by reporting ordinary operating costs as R&D costs in each group is representative for the whole population of beneficiaries, we can quantify the total amount of R&D expenses that could have been misreported between 2008 and 2016. We call this the upper bound of misuse.

Figure 8.9 illustrate our estimate for the upper bound of falsely reported R&D costs in billion NOK. The figure show that the estimate increased from about NOK 0,5 billion to slightly less than NOK 2 billion between 2008 and 2016. This increase corresponds to the increase in the total R&D costs, which is increasing with the schemes generosity.

Figure 8.10 Upper estimate for the fictive R&D costs in billion NOK by low and high-risk firms on the left and total R&D costs on the right



Source: Samfunnsøkonomisk analyse AS and The Norwegian Tax Administration

[122] Information on risk criteria is not available for 2002-2007, hence, we cannot conduct the same analysis for earlier years of SkatteFUNN use.
[123] Indeed, as discussed earlier, small firms with large projects can have higher incentive to misuse the scheme.
[124] The auditor selected only 10 invoices from the firms' 2016 accounts, hence there is not possible to know the overall scope of misreported R&D.
[125] For 2008, the share of R&D expensed belonging to the high-risk group is slightly lower, with about 37 per cent.

Table 8.1 summarises the estimated impact of misuse on input additionality, under the assumption that none of the firm's reported R&D costs satisfy the criteria for being eligible for tax credit.[126] The BFTB is adjusted by removing R&D costs defined as fictive from the estimated additional R&D investment.

Table 8.1 BFTB before and after considering misuse

Year	Original BFTB[127]	BFTB after deducting estimated fictive R&D costs
2008	2,40	1,71
2009	2,03	1,38
2010	1,87	1,30
2011	1,73	1,13
2012	1,47	0,88
2013	1,60	1,00
2014	1,78	1,19
2015	1,46	0,87
Average	**1,79**	**1,18**

Source: Samfunnsøkonomisk analyse AS

Table 8.1 display that public spending on SkatteFUNN still contributes with additional R&D, even if we utilise the upper bound of misreported R&D costs. For most years the BFTB is larger than one, indicating that for every krone in forgone tax revenue, investment in R&D increase by more than one krone. Although the input additionality is significantly lower after including our assumption that firms reporting fictive R&D costs do not have any real R&D costs at all, it is not particularly low in an international comparison. As discussed in chapter 3 and 4, several international studies have found that one euro of foregone tax revenue on R&D tax credits raises expenditure on R&D by about one euro.

The assumption of all R&D costs as fictive in case of the revealed misreporting is unrealistic. The beneficiaries reporting ordinary costs as R&D typically do have some actual R&D costs, however the ratio of actual and fictive costs is unknown.[128] Hence, we conclude that the input additionality lies somewhere between the two estimates for BFTB illustrated in table 8.1, and likely significantly closer to the original BFTB.

8.7 How can compliance be ensured?

At present we do not have sufficient data to assess with certainty how widespread the misuse of SkatteFUNN is, as well as the corresponding forgone tax revenue. To this end, more audits are needed.

However, the performed audits have been useful identifying different ways of misusing SkatteFUNN. Due to the existing indications of misuse, the non-compliance of the formalities in the scheme, and the increasing magnitude of the scheme, it seems obvious that more audits should be set in place and that the regulations regarding SkatteFUNN should be altered to prevent and limit misuse.

RCN and The Norwegian Tax Administration are currently collaborating on different strategies to limit and prevent misuse, for example enabling the institutions to share information about SkatteFUNN projects, establishing better methods and routines for audit, and making regulations and guidelines clearer.

Below is a list of measures that are recommended for consideration based on this evaluation. It is crucial with a clear division of responsibilities, and we suggest that it falls upon the Norwegian Tax Administration to manage these recommendations.

- **Auditors responsibility:** When claiming the tax incentive, this must be done in a form certified by the firm´s auditor and specifying the different types of costs. In practice, the process of auditing whether a certified auditor has in fact

[126] We have estimated the input additionality till 2015, cf. chapter 4, hence we cannot quantify the impact of misuse on input additionality for 2016.
[127] See chapter 4.4.
[128] If we for example assume that half of project cost are misreported as R&D, then the adjusted overall BFTB estimate would be equal to 1.5.

audited the firms' R&D costs is inefficient. We suggest implementation of a digital signature for authorised auditors, similar to the signature related to the personal tax returns. With such a signature, one could make sure that claims lacking a signature where refused. Furthermore, the regulation should specify the obligations of the approving auditor, including ensuring and guaranteeing that the requirements for approval are met.

- **Ensuring correct hours**: We suggest that firms and auditors are required to ensure that employees working on the R&D project confirm their project engagement.[129] This could involve a required signature by all employees on their own hours used to work on the project.
- **Limit R&D contribution from other firms in a group:** Goods and services for R&D purchased from other firms in a corporate group should only be allowed in the SkatteFUNN-accounts if the supplier has agreed to present accounts for delivery to the tax authorities together with the SkatteFUNN claim. The accounts must confirm that the delivery has taken place, and that the pricing is in accordance with the arm´s length principle.
- **Limiting the involvement of foreign firms:** To cope with the issue auditing international firms, an option could be to limit the opportunity to purchase R&D from firms outside the EEA area or strengthen the documentation requirements. In addition, R&D purchased from foreign countries should only be entered into the SkatteFUNN-accounts if Norway has an agreement with the country on collaboration in tax matters.
- **Reporting the sale of R&D results:** As part of the reporting, the firm should be obliged to confirm that the R&D results are for the firm's own purpose, and have not been licensed to any other firm, for example in a corporate group, without being sufficiently paid. This should be made clear in the approval application and needs not be repeated. An obligation report on the sale or licensing within a group would only be efficient if it was a general obligation attached to future tax returns. Whether such a rule is well enough justified when taking into consideration the ambition of simplifying tax matters is not obvious.
- **Audits:** Both RCN and the tax authorities should increase the frequency of audits. Both RCN and the tax authorities should establish risk-based models for identifying applications that should be given enhanced assessment and projects/firms that should be inspected. We also recommend random tests to reveal misuse. This will make the scheme easier to evaluate and have a deterrent effect. This would in turn improve the legitimacy of SkatteFUNN. These audits could also be at least partly self-financing, by reducing public expenses on the scheme, but also possibly through a fee to be paid by firms at fault.

  Sanctions: Sanctions could include reclaiming the incorrect tax credit retroactively, imposing additional punitive taxes and normal penal sanctions such as fines or prison punishment.[130] Another possible sanction, which no countries currently have implemented, is that firms misusing the tax incentive is barred from claiming it for some years and/or become subject to special audits requirements for the next applications or claims. The only move in this direction identified is in the UK, were it is proposed to introduce sanctions. Under the proposal, a 'serial avoider' repeatedly exploiting R&D tax relief in a way not intended, could be denied access for a period of three years. In its

[129] This requirement does already follow the regulations. The problem is that it is probably not followed up properly by firms and auditors.

[130] All these sanctions are included in the taxation law and apply also in the SkatteFUNN context.

‘Advance Assurance’ scheme, HMRC rules deny the use of this scheme to firms that have used tax avoidance schemes or are ‘serious defaulters’. Furthermore, we suggest increasing the responsibility of the auditors. Auditors incorrectly approving a SkatteFUNN-claim should be barred from approving such claims for an appropriate number of years and identified in a public register.

9 Impact on competition and trade

We have assessed SkatteFUNN's impact on competition and trade, containing both positive and negative elements. Firstly, SkatteFUNN is neutral by design. Being a general scheme, there is no selection bias related to receiving SkatteFUNN. Neutrality is achieved along most domestic dimensions, including geographic location, industry, ownership, result, and subject of research. There is, however, a slight favouring of SMEs, which arguably has a positive impact on competition as it reduces the entry barriers and counteracts the bias towards large firms by other available R&D schemes. We do not find any evidence that firms receiving SkatteFUNN have any negative impact on non-beneficiaries.

Internationally, we find that a relatively small share of the exporting beneficiaries receives aid above the limit of de minimis aid. It is important to note that even if support exceeds this limit, it is not sufficient to conclude that there is an impact on competition and trade. Furthermore, beneficiaries of SkatteFUNN are found to import more from foreign firms, which is a positive impact on Norway's trading partners.

To the extent SkatteFUNN impacts competition and trade, this is probably applicable also to most of the other member states having similar arrangements, levelling out the distortions. Overall, we argue that the positive impact on competition and trade outweigh the negative.

9.1 SkatteFUNN and potential impact on trade and competition

Schemes implemented to enhance R&D are typically meant to remedy the suboptimal level of investment caused by the presence of externalities and informational asymmetries, as discussed in chapter 2. However, one should bear in mind that this kind of aid also may give rise to inefficiencies.

Schemes that limit competition are prohibited by EU law, unless they are targeted at specific objectives of EU interest and distortions of competition and trade are kept at an acceptable level.[131] It is important that measures enhancing R&D bring about a higher level of R&D activities than would otherwise occur, while ensuring that the positive effects outweigh potential negative effects in terms of distortions of competition in the internal market.

Uniform rules on R&D State aid at the EU level are necessary to ensure uniform conditions for the granting of aid. A situation without rules would not ensure equal treatment, legal certainty or predictability, and could lead member states to compete on measures, which could highly damage trade and competition within the internal market. However, even though the state aid rules apply within the EU, there is a large variation between countries in terms of how much R&D support is given. Thus, the treaty does not guarantee the same conditions of competition at this point.

Information related to SkatteFUNN has been transmitted to the EFTA Surveillance Authority, (ESA) in accordance with the provisions of the EU regulation 651/2014, as a scheme exempted from the notification requirement in the EEA agreement art 62. The size of SkatteFUNN implies that the Norwegian authorities are obliged to conduct an impact evaluation in line with the European Commission Staff Working Document, *Common methodology for State aid evaluations*. An important aspect of this evaluation is to assess SkatteFUNN's potential impact on competition and trade.

[131] According to Article 107(1) of the Treaty on the Functioning of the European Union (TFEU). The Treaty places the responsibility for the control of State aid in the hands of the European Commission.

In general, R&D tax incentives typically passes the exemption for state aid by ESA, if the scheme is not focused on certain areas of specialization or regions. Direct grants and subsidies however, being more focused by definition, will more likely favour some firms and hence potentially harm competition.

To analyse the possible distortions on competition and trade of SkatteFUNN we must consider several factors, pointed out by the European commission in their guide for balancing the positive and negative impact of state aid.[132] The overall objective of a State aid evaluation is to assess the positive and negative effects of a scheme.

In this chapter we assess the effects SkatteFUNN may have on the domestic and the international competitive environment, respectively:

- Domestically, any governmental measure can potentially be distortive, this is especially the case if there is a certain degree of selectivity, i.e. if it is directed to a specific industry or region that are enabled to increase their marked share, and thus distort competition. Marked shares can be gained through SkatteFUNN enabling firms to increase the quality of their products (if additionality is high) or reduce their prices (if additionality is low).
- Internationally, beneficiaries of SkatteFUNN can also potentially increase their market share at the expense of foreign firms. An important indicator of potential distortion is the scope of the aid and the beneficiaries' level of activity in international markets. According to EU regulation, if total aid received by a firm is less than € 200,000 over a three-year period, it is deemed as not large enough to have an impact on trade and competition. It is important to note that even if support exceeds this limit, it is not necessarily impact competition or trade.

In this chapter, we will consider SkatteFUNN's possible impact on competition and trade, focussing on domestic competition effects first and then on international competition and trade effects.

9.2 Domestic competition

The impact of SkatteFUNN on domestic competition will depend on firms' access to aid. The neutral nature of SkatteFUNN limits its distortive potential. Being a rights-based scheme, there is no selection bias related to receiving SkatteFUNN.

However, we find that SkatteFUNN is used more by firms and industries with a large share of R&D activity. For example, a larger share of firms in the ICT industry and technical services benefits from SkatteFUNN, compared to for example firms in health care. However, it is important to note that R&D intensity is endogenous, meaning that the R&D intensity of firms or industries can change. For example, due to SkatteFUNN, but more likely due to their competitive environment or income. The main question is whether SkatteFUNN succeeds in lifting R&D investment (closer) to the socially optimal level as described in chapter 2, without causing unduly market distortion.

SkatteFUNN's neutrality gives all firms the opportunity to receive tax credit for R&D expenses

R&D tax incentives typically give lower distortive effects on domestic competition compared to direct R&D subsidies, because they do not target specific sectors or industries and do not interfere with market mechanisms.[133]

[132] See Common principles for an economic assessment of the compatibility of State aid under Article 87.3.

[133] However, several of the international R&D tax incentives target certain firm characteristics, making them less neutral than SkatteFUNN. For example, some schemes have a lower tax deduction for foreign-owned firms, as is the case in Canada.

Although there is no bias related to receiving SkatteFUNN, the impact of the scheme can be biased. R&D tax incentives can have a bias toward incumbents or firms with a high degree of market power as they are more inclined to utilise the cost ceilings of the scheme to enhance their production. On the other hand, lowering the investment costs of R&D might lower entry costs, and thereby increase competition. Finding that the majority of SkatteFUNN beneficiaries are SMEs, the latter seems more likely.

When assessing SkatteFUNN's impact on competition, it is also relevant to compare SkatteFUNN with other R&D enhancing instruments. When SkatteFUNN was implemented, an important argument was that it would reduce the barrier for SMEs to engage in R&D activities. It is not the case that SkatteFUNN exclude larger firms, it is rather the case that other R&D enhancing instruments exclude SMEs. This is often due to a complicated application process or requirements for the project that cannot be met by SMEs. We therefore argue that SkatteFUNN contributes to reducing an inconvenience experienced by SMEs due to the design of the portfolio of measures enhancing R&D. Increasing the market shares for SMEs is a positive impact of SkatteFUNN, creating a healthier competitive environment.

Another important and accredited characteristic is that the tax incentive is refundable as cash for firms who are not tax liable (Elschner, Ernst, Licht, & Spengel, 2011). The idea is that the disbursements will particularly strengthen the liquidity of SMEs in the start-up phase, when R&D activities have not yet resulted in income. Including disbursements as an option arguably makes the scheme more neutral because it enables all firms to gain from SkatteFUNN, not only the profitable ones.

If SkatteFUNN is used as a means of survival or prevention of exit for unprofitable firms, then this is an unwanted consequence. It is not the objective of SkatteFUNN to affect the industrial structure, and funding unprofitable firms would be unintentional and unwanted. It could also potentially be a sign of misuse of the scheme if firms benefit from a generous public scheme to keep their business afloat.[134]

Finally, in a case of low or zero additionality, i.e. if firms receive support for R&D activity they would have done anyway, SkatteFUNN could be used to compete on pricing. In practice, we do not regard this an issue, as we find evidence of high additionality.

Ceilings may cause unwanted firm behaviour

Cost ceilings indirectly target firms based on their size, as smaller firms tend to have relatively lower costs related to R&D, compared to larger firms. Hence, smaller firms are more likely to have project expenses below the ceiling. In addition to the cost ceilings, SkatteFUNN does favour SMEs by entitling them to a tax deduction of up to 20 per cent on their R&D project costs, compared to 18 per cent for large firms. As argued above, this slight favouring of SMEs does not have a negative impact on competition, rather it enhances competition by providing market shares to SMEs.

A disadvantage of ceilings is that they provide an incentive to distribute expenses on R&D over time and over subcontractors to obtain the maximum tax credit. When it comes to SkatteFUNN, the incentive to make such adjustments is only relevant for larger firms. In 2015, only about 4.5 per cent utilised the cost ceiling for internal costs of R&D projects, and

[134] See chapter 8 from more about this potential for misuse.

less than 0.5 per cent utilised the full cost ceiling of both intramural and purchased R&D costs from an approved institution. That only a small share of firms utilise the full cost ceiling indicate that this is probably not a significant issue.

The impact of SkatteFUNN on non-beneficiaries

That the tax deduction is not received by all firms, may cause a negative impact on competition and trade. Firms benefitting from SkatteFUNN can potentially increase their market share, at the expense of firms who does not receive support from SkatteFUNN. We argue that the neutrality of the scheme limits this distortion.

Furthermore, we have estimated the reaction of a given firm to changes in R&D expenditure made by other firms belonging to the same industry or geographic area. We do not find that the productivity of firms without own R&D activity is significantly affected by being part of an R&D intensive industry or located in an R&D intensive area. For more information on this see chapter 5. This supports our argument that the potential negative impact on firms who do not benefit from SkatteFUNN is limited.

9.3 International competition

The growing number of countries with R&D tax incentives reduces the chance of impact on competition and trade internationally, see e.g. Cunningham, Shapira, Edler and Gok (2016). In the US, where 40 states have introduced R&D tax credits, they argue that the measure is no longer an incentive, but a prerequisite. In the EU 22 of 28 countries have implemented some sort of R&D tax incentive (OECD, 2016).

For SkatteFUNN to have a impact on international trade, at least two conditions must be fulfilled. Firstly, support must be given to Norwegian firms selling goods and services on the international market. Secondly, the amount of aid granted must be of such a magnitude that it is likely to affect the firm's market adaptation at the expense of foreign firms without access to an equivalent aid. SkatteFUNN may also have an impact on international competition by enabling beneficiaries to gain market shares. However, most of the foreign firms are registered with a Norwegian organisational number and could therefore themselves receive a tax deduction through SkatteFUNN.

In this chapter we will discuss the potential for impact on international competition by SkatteFUNN, including an empirical analysis of the international activity by beneficiaries of SkatteFUNN.

Tax incentives can distort firms' location decisions and profit shifting

A large body of literature has documented that differences in corporate taxes are important for the location of a firm's capital and profits (Straathof, et al., 2014). Firms have an incentive to arrange their activities in such a way that, all else equal, profits accrue in the country in which they would pay the lowest tax. The existence of an R&D tax incentive in a country can generate a negative externality for private investment in R&D in neighbouring countries. Firms are not established where their social return is highest, but where they can receive the most aid. If such negative externalities exist, then non-collaborative governments are likely to compete for the highest tax incentives.

There are several strategies that can be used by firms to exploit generous R&D tax incentives in other countries. Such strategies commonly require that the income earned from exploiting intellectual property or other gains from R&D activities accrues outside of the country in which the underlying R&D took place. One way to achieve this is through contract R&D. For example, a subsidiary in a country with relatively low taxes may finance (and bear the

risk of) R&D activities that are contracted to a related subsidiary in a country with generous R&D enhancing measures. The contract will specify the payment to be made for the R&D activities. There is a tax advantage to this strategy if the costs of purchasing the R&D is inflated or if the true value of the R&D activities is less than the price paid for the contract R&D.

A similar result may be achieved using a cost sharing agreement that specifies how subsidiaries will share the costs, risks and returns associated with an R&D project. Such agreements may be designed to exploit and capture the returns from R&D accrued by a subsidiary in a low tax country (Griffith, Miller, & O'Connell, Ownership of intellectual property and corporate taxation, 2014).

Straathof et al. (2014) concludes in their meta study that it is especially large multinational firms that engage in profit-shifting activities to decrease the overall tax liabilities. Intangible assets, like patents, play an important role as they are relatively easy to move from one location to another. In addition, for large firms, innovation often is an international activity. Firms may perform R&D in one country, patent the product in another and commercialize it in a third one. Studies show that a strong negative relation persists between corporate income tax and the number of patents registered in a country (Straathof, et al., 2014). SMEs have less opportunity to conduct income shifting activities or tax planning (Bartelsman & Beetsma, 2003). All this may distort competition and result in overall lower welfare.

Grubert (2003) studied parent firms from the US and their manufacturing subsidiaries and found that R&D related intangible assets were responsible for around half of the income that was shifted from high-tax to low tax countries. Transactions among the affiliations of a firm are hard to tax properly as it is difficult to assess the price of services within a firm. The reason for this is that intangible property transferred within a firm is very firm-specific. A comparable transfer may not exist in the market, and its price is therefore not observed.

De Mooij and Ederveen (2003) found in their meta study that a decrease by one percentage point in the host country's tax rate leads to an increase of foreign direct investment by around 3.3 per cent. Desai et al. (2006) utilise firm level data of American firms to conclude that R&D expenditures are especially sensitive to changes in corporate taxes. For states in the US, Wilson (2009) finds that R&D tax incentives attract R&D from other states, while the overall amount of R&D is not affected. Indicating a distortion of firms' localisation decisions. However, the study does not include documentation of whether the scheme attracts foreign firms, i.e. from outside the US. There are reasons to believe that the locational effects of such schemes are less pronounced elsewhere. In Europe, and for some factors maybe for Norway in particular, the differences between countries in language, currency, culture, climate, and so on will differ far more than between states in the US. Furthermore, considering the relatively modest ceiling for SkatteFUNN and the fact that the scheme provides a tax credit for just 18 to 20 per cent of the total R&D investment costs, the remaining 80 to 82 per cent must be paid by the firm itself, it seems unlikely that SkatteFUNN provides sufficient incentives for international firms to relocate to Norway to a significant extent.

In 2015, only 2.5 per cent of firms in Norway were subsidiaries audited directly or indirectly by foreign firms. About half of these firms were audited by owners in the Nordic countries. The share has been weakly increasing over several years, but there has been a decrease in their investment in 2014 and 2015. These are years where the ceilings of SkatteFUNN increased significantly. It is important to note

that, although the share of foreign audited firms in Norway is fairly small, the foreign owned firms are large. Around 40 per cent of firms in Norway with more than 250 employees are indirectly or directly owned by a foreign firm.

To say something about SkatteFUNN's impact on foreign firms' decision to set up a subsidiary in Norway, it is relevant to look at the establishment of firms owned by foreign firms from countries without an R&D tax incentive. In the evaluation of the Austrian scheme, Ecker et al. (2017) found a positive impact of their R&D incentive on the attraction of foreign firms to Austria, and in particular from Germany, who does not have an R&D incentive. In Norway, the share of foreign audited firms that is audited by a German firm is only 4.6 per cent in 2015. The share has also been decreasing as the generosity of SkatteFUNN increased. Although we cannot state the explicit causal relationship between SkatteFUNN and the attractiveness of Norway to locate R&D intensive firms, the statistics do not indicate substantial relationship.

Griffith, Miller, & O'Connell (2014) model the impact of taxes on where firms choose to locate the legal ownership of patents. They find that corporate tax rates are an important determinant of locational choice. However, the number of patents applied for in Norway does not seem to be sensitive to corporate tax changes in other countries. This is an indication that lower taxes in Norway, relative to other European countries, may not attract foreign investment in R&D (Griffith, Miller, & O'Connell, Ownership of intellectual property and corporate taxation, 2014).

This must, nonetheless, be interpreted with caution as patents registered in a country does not necessarily reflect innovativeness. The country from which a patent is applied for is not necessarily where the invention originated (Straathof, et al., 2014). Especially larger firms might apply for patents from countries other than those where they perform their R&D, as they tend to have subsidiaries dedicated to IP-issues, possibly due to patent advantages in countries with patent box schemes.[135]

The introduction of patent boxes by several European countries in a relatively short space of time has given rise to concerns that countries are engaging in tax competition for patent income. The European Commission (2016) is amongst those preferring tax allowances or credits based on R&D costs, rather than patent boxes. This is because few studies find a stimulating impact on R&D from patent boxes, but several studies find that these schemes are used as a profit-shifting instrument (Alstadsæter et al., 2015). Straathof et al. (2014) also argues that patent boxes, rather than tax incentives, are utilised for profit-shifting operations and that it leads to unwanted tax competition between the countries.

Compared to the US, European firms are less likely to move or start subsidiaries due to changes in tax policy. Dischinger et al. (2014) found that the profits of European multinationals tend to concentrate in the country of their headquarters. They showed that the volume of profit-shifting from a higher-tax subsidiary to a lower-tax headquarter was around seventy per cent larger than the volume running from a high-tax headquarter to a low-tax subsidiary. However, the intangible asset investment and patent applications do flow to those subsidiaries that, relative to other subsidiaries, have lower tax rates (Griffith, Miller, & O'Connell, Ownership of intellectual property and corporate taxation, 2014; Dischinger & Riedel, 2011; Karkinsky & Riedel, 2012).

[135] Patent boxes refers to preferential tax regimes for income from patents.

More generally, there may be characteristics of a location over and above its corporate tax rate that firms value. For example, the strength of intellectual property rights protection and market size might play a role, and, all else equal, firms may be more likely to co-locate ownership of intellectual property with associated real innovative activity due to externalities from co-location (Griffith, Miller, & O'Connell, Ownership of intellectual property and corporate taxation, 2014).

Multinationals have wide access to finance and cross-border tax planning possibilities that put them at an advantageous position with respect to domestic firms. Additional support to multinationals could result in large dead-weight losses and a distorted competitive environment. A solution could be to reduce the tax incentives for large multinational firms or limit the project costs of R&D activities performed outside of the country. This is something that can be considered as part of SkatteFUNN.

None of the European countries studied in Griffith, Miller and O'Connell (2014) require that the R&D underlying the intellectual property took place in the country providing the tax incentive, as this is not permissible under European law.[136] However, both Canada, Australia and the US are amongst the countries that maintain provisions that the R&D activities must be performed in the country eligible for tax incentives (partly or fully). Some other countries maintain provisions that intellectual property rights resulting from R&D are owned by the country providing the tax incentive.

SkatteFUNN is arguably a scheme that enhances the competitive environment for SMEs, who are not able to participate in profit-shifting activities, rather than being a scheme distorting international firms' location decisions (Bartelsman & Beetsma, 2003).

SkatteFUNN beneficiaries import more

Bøler, Moxnes and Ulltveit-Moe (2015) studied the impact of an R&D cost shock on R&D investment, imported inputs and their joint impact on firm performance. The R&D cost shock is SkatteFUNN. By including imported inputs into a model of R&D and endogenous productivity, they show that R&D and international sourcing are complementary activities. The complementarity arises because R&D on average increases future profits, and therefore increase the profitability of cutting costs by sourcing inputs internationally, while enhanced international sourcing in turn makes R&D investment more profitable.

They also found that receiving support through SkatteFUNN did have an impact on firms R&D investment, but more importantly in this aspect; beneficiaries of SkatteFUNN purchased more intermediates from foreign firms, compared to other firms. This indicates that SkatteFUNN has a positive external impact on foreign firms as the demand for their products increases.

SkatteFUNN and exporting firms

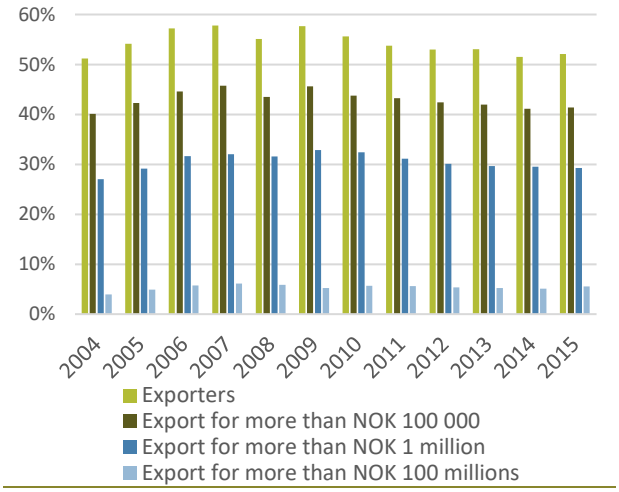
For SkatteFUNN to have a negative impact on international trade, the benefitting firm must be an exporter or strengthen its competitiveness in the Norwegian market compared with foreign suppliers.

Figure 9.1 illustrates that around half of the benefitting firms are exporting. However, the exporting value for most of these are relatively low. The median export value of the exporting SkatteFUNN beneficiaries was slightly above NOK 2 million in 2015. Figure 9.1 also illustrates that the share of exporting

[136] The countries studied includes Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Spain, Norway, Sweden, Switzerland and the UK.

SkatteFUNN beneficiaries, by value of export, is relatively stable. Around 30 per cent of the SkatteFUNN beneficiaries export for more than NOK 1 million.

Figure 9.1 The share of SkatteFUNN beneficiaries who export, by value of export



Source: XX

In addition to being an exporter, the amount of aid granted must be such that it likely will affect the firm's market access at the expense of firms in other countries, that do not have access to an equivalent scheme.

We do not have access to the international firm level data necessary to estimate the impact of SkatteFUNN on international firms. We can therefore not conclude on the aggregated effects of SkatteFUNN on international competition and trade. We do, however, have access to information about the Norwegian firms and aid from SkatteFUNN.

The median size of tax deduction for exporting SkatteFUNN beneficiaries was slightly less than NOK 700,000 and the maximum was NOK 6,6 million in 2015.[137] It was, however, only one exporting firm who utilized the increased ceiling in 2015 for intra- and extramural R&D. The increased ceiling provides a useful contribution to larger firms, but our findings indicate that a relatively small number of firms can utilise such a large cost ceiling.

For the firms who exported but were not tax liable and therefore received a cash payment through SkatteFUNN, the median was slightly above NOK 350,000.

According to EU regulation, aid received by a firm amounting to below € 200,000 for a three-year period is deemed as not large enough to have an impact on trade and competition (de minimis aid).[138] Support above this limit does, however, not necessarily have an impact on trade, but it might.

The € 200,000 for a three-year period is equivalent to slightly less than NOK 650,000 per year. When it comes to SkatteFUNN beneficiaries, most have been below this limit for almost every year since SkatteFUNN was implemented, cf. Figure 9.2. However, with the large increases in generosity over the past few years, due to the rising ceiling, several firms receive tax deductions above this limit.

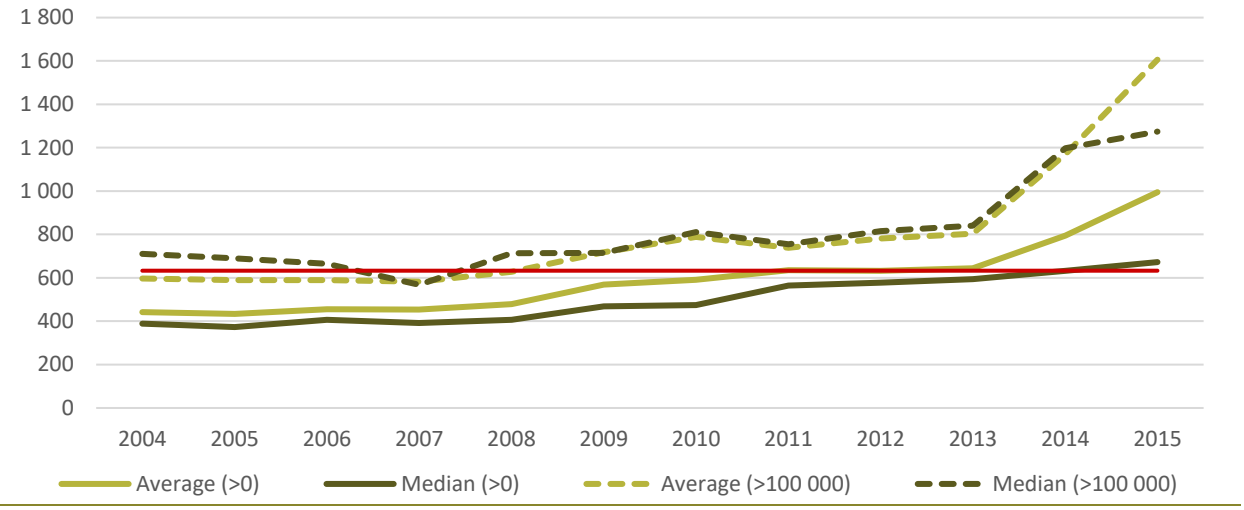
The share of firms exceeding the limit has increased significantly with the expansions of SkatteFUNN. In 2015, there was a significant share of exporting firms above the limit. It follows that we cannot rule out effects on trade based on this formal definition.

However, the value SkatteFUNN firms' exports is typically relatively small. To have a negative impact on international competition and trade the exported value must be of a certain size and the aid received must be above the limit for *de minimis aid*.

[137] This is significantly larger than the median aid given to SkatteFUNN beneficiaries in total.

[138] See the Official EN Journal of the European Union for more information.

Figure 9.2 Development of average and median tax deduction through SkatteFUNN by value of export in NOK 1 000



Source: Statistics Norway and Samfunnsøkonomisk analyse AS

The share of exporting beneficiaries receiving support from SkatteFUNN above the limit for *de minimis aid* is very low, but higher for firms with high export value. Figure 9.2 illustrates that a significant share of firms exporting values above NOK 100 million is above the limit for *de minimis aid* (the red line) for most of the years. However, the share of exporting SkatteFUNN firms who export for more than NOK 100 million is only about 1 per cent for the whole period. The activities of these large exporting beneficiaries are relatively evenly spread across industries. Indicating that they do not distort any single industries. The industries with the highest share of SkatteFUNN firms exporting for more than NOK 100 million per year included manufacture of other inorganic basic chemicals, instruments for measuring, testing and navigation, other parts and accessories for motor vehicles and aquaculture.

Whether activities performed by exporting firms receiving state aid above the limit has an impact on trade and competition is uncertain. Nevertheless, we cannot disregard that SkatteFUNN does have a negative impact on trade and competition. However, given its modest scope per beneficiary and the fact that most other OECD countries have similar schemes, we view it as unlikely that such an impact would be large.

9.4 Does SkatteFUNN impact competition and trade?

The question boils down to whether the costs of negative distortions are greater than the benefits from SkatteFUNN, including the benefits on competition. We will return to the other benefits of SkatteFUNN in chapter 10. In this chapter we will conclude on the net impact of SkatteFUNN on competition and trade.

There are several reasons why SkatteFUNN is unlikely to contribute to a net negative impact on trade and competition. We distinguish between domestic and international impact on competition and trade.

Domestically, any governmental measure can potentially be distortive, this is especially the case if there is a certain degree of selectivity, i.e. if it is directed to a specific industry or region that is enabled to increase its market share, and thus distort competition. Marked shares can be gained by SkatteFUNN enabling firms to increase the quality of their

products (if additionality is high) or reduce their prices (if additionality is low).

SkatteFUNN is neutral by design. Being a rights-based scheme, there is no selection bias related to receiving SkatteFUNN However, one exception is that SkatteFUNN does favour SMEs (both as a consequence of the efficient application process, the more favourable tax rate for SMEs and the cost ceilings). This is as intended, and arguably has a positive impact on the competitive environment as it reduces the entry barriers and counteracts the bias towards large firms by other available R&D schemes.

We find a high and positive additionality of SkatteFUNN, especially for small projects – which are typically found in smaller firms (cf. chapter 4). This implies that market shares can be gained by beneficiaries due to increased product quality. Increasing the market shares for SMEs is a positive distortive impact of SkatteFUNN, creating a healthier competitive environment.

However, with the scheme's generosity expanding significantly over the past few years, the potential impact on competition and trade has risen. Given that a small share of firms utilises the new, higher cost caps we do not recommend further increases of the cap.

Internationally, we find that a relatively small share of the exporting beneficiaries receives aid above the limit of *de minimis aid*. It is also important to note that even if support exceeds this limit, it is not sufficient to have an impact on competition and trade. Furthermore, beneficiaries of SkatteFUNN are found to import more from foreign firms, which is a positive externality for Norway's trading partners.

Overall, we argue that the net impact of SkatteFUNN on competition and trade appear to be positive.

10 Concluding remarks and recommendations

The main objective of this evaluation has been to assess the extent to which SkatteFUNN increases R&D investment in the private sector, especially among SMEs.

The evaluation has been carried out in accordance with the European Commission's guidelines as stated in the Commission Staff Working Document, *Common methodology for State aid evaluations.* We have evaluated whether:

- SkatteFUNN is aimed at a well-defined objective of common interest
- SkatteFUNN is designed to deliver the objective of common interest
- the distortions of competition and effect on trade are limited

This chapter summarise our findings and provides our recommendations for further development of the scheme.

10.1 The objective is well-defined

Our review of the rationale of SkatteFUNN confirms that both NOU 2000: 7, which laid the foundation for SkatteFUNN, saw enhanced R&D in the private sector as necessary for promoting productivity and future economic growth.

SkatteFUNN was proposed as one of several measures to increase R&D in the private sector. As a general tax credit scheme that reduces the cost of R&D investment, the motivation for SkatteFUNN was primarily the need to complement other innovation-promoting schemes, which were (and are) application-based.

NOU 2000: 7 highlighted that SMEs' use of existing schemes was limited. The committee therefore concluded that a general tax credit scheme would complement existing schemes by also stimulating smaller R&D projects, typically for SMEs.

We consider the objective of SkatteFUNN as well-defined, namely to provide broad incentives for private sector R&D investment.

Economic theory provides strong support for the scheme's prerequisite that R&D investment by one firm have a beneficial impact on other firms and the overall economy. It is reasonable to assume that private sector R&D investment will also increase the number of innovative projects. Successful innovation causes productivity growth, production opportunities and value added in society. These external effects are not fully internalised by the individual decision-makers, and government intervention can be used to correct for this market failure.

Furthermore, it is often difficult for firms to obtain funding for innovation projects in the private market. Information possessed by the firm and the investor is typically highly asymmetric, implying higher investor risk. The market failure of asymmetric information reduces the scope of R&D projects and is therefore also an argument for government intervention.

10.2 SkatteFUNN is designed to deliver the objective of common interest

On balance,

a) SkatteFUNN satisfies the operational target of higher R&D investment in the private sector and in SMEs and smaller projects in particular,
b) such investment fulfils the ambition of more innovation and higher productivity,
c) SkatteFUNN seems appropriate and well-proportioned to achieve the targets although some adjustments are recommended, and
d) Misuse of the scheme does occur but may be reduced by relatively simple means.

Thus, our evaluation leads us to conclude that SkatteFUNN is designed to deliver the objective of

common interest. However, we have suggestions for improving appropriateness and proportionality and to reduce misuse of the scheme.

Private sector R&D enhances productivity

In chapter 5, we have tested whether Private sector R&D investment have a positive and significant impact on labour productivity, and thus on the overall economy.

A positive impact on productivity is an argument for government support of private sector R&D investment because it compensates for the fact that individual firms do not internalise all the social benefits of their own R&D investment.

On balance, the results show that, over time, R&D investment in the private sector generally enhances labour productivity. Moreover, our results tell us that projects in firms using SkatteFUNN and firms receiving direct support from the RCN have the same effect on labour productivity as R&D projects fully financed by the firms themselves. This is consistent with the results of the previous evaluation of SkatteFUNN.

The external effects of R&D are difficult to measure quantitively. We apply a “distance to R&D” approach, but the results of this econometric analysis are inconclusive.

However, the survey conducted as part of this evaluation provides some answers: Firms were asked what impact their SkatteFUNN projects might have had outside the firm. The most frequently reported impact was that the projects benefited the firms’ customers, mainly in terms of better goods or services. Moreover, most respondents answered that strengthened competitiveness for other firms and dissemination of competence through staff mobility and cooperation were results of the SkatteFUNN projects.

The results of the survey substantiate that it is possible to achieve social gains by increasing private sector R&D investment. However, SkatteFUNN has this effect only if the scheme realises projects that would not otherwise have been realised.

High and positive input additionality

In chapter 4 we have conducted a comprehensive estimation of the scheme’s input additionality, i.e. the firms’ R&D investment that can be attributed to SkatteFUNN.

We apply two different approaches to estimate the input additionality of SkatteFUNN. The first approach evaluates the effect of an increase in the project cost cap in 2009. This approach confirms that only firms with R&D spending below the project cost cap are stimulated to increase their R&D investment.

The second approach is more general and studies how different changes in the scheme have affected firms’ R&D investment. This approach shows that SkatteFUNN has high input additionality, but effects vary a lot depending on the type of change and the type of user-generation.

We define a generation as the new users linked to a certain change in the scheme, leading in turn to what we call a new regime. Weighted over all generations, input additionality decreases over time. This is because new generations are associated with lower additionality, while the earlier generations tend to maintain their higher additionality over time/regimes. Our interpretation is that the most competent firms were also the most efficient at signing up for SkatteFUNN. It follows that a large share of the initial pool of highly efficient firms signed up at the introduction of the scheme, and therefore account for an ever-smaller proportion of the following generations.

SkatteFUNN is appropriate and well proportioned

Around half of the recipients of SkatteFUNN are firms with less than 10 employees. The share is lower than the share of small firms in the private sector as a whole, mainly because many small firms do not use SkatteFUNN. However, the share of firms with less than 10 employees is significantly larger than the share in comparable R&D supporting schemes (e.g. the RCN's BIA) (Røtnes, Flatval, & Bjøru, 2017).

The share of small firms among those who continuously used SkatteFUNN has decreased somewhat over time. This is reasonable, given that the bulk of recipients are firms that continue to use the scheme; size tends to increase with firm age.

Among new applicants, the share of firms with less than 10 employees has been relatively stable over time. More than 80 per cent of all applicants, new as well as "regulars", are firms with less than 50 employees.

The share of SMEs using SkatteFUNN is much higher than for comparable R&D schemes. There is reason to assume that the relevance for SMEs is largely a consequence of SkatteFUNN's fundamental nature as a general, rights-based scheme. SkatteFUNN differs from direct subsidy schemes in which aid is more targeted and requires a more comprehensive approval process. Firms supported by SkatteFUNN can decide themselves which projects to invest in, as long as they create new knowledge or new experience in association with development or improvement of goods, services or processes.

In sum, it is our clear assessment that SkatteFUNN meets its objective and is well designed to do so.

Measures aimed at preventing misuse are needed

We have used selected indicators and randomized controls in collaboration with the Norwegian Tax Administration to analyse misuse of SkatteFUNN.

Reported R&D investment is to a large extent based on trust, and there have not been any strategic control routines for recipients of SkatteFUNN. Cases have been found of firms misusing the scheme, for example by claiming reimbursement for more hours than were actually used or reporting ordinary operating costs as R&D investment.

Discrepancies between hours reported to the government and firms SkatteFUNN claim were found for about 10 per cent of the inspected firms. About 13 per cent of the firms reported ordinary costs as R&D investment.

Based on the characteristics of the inspected Skattefunn recipients, we have estimated the *upper bound* for misuse in the form of reporting ordinary operating costs as R&D investment. After adjustment for misuse, SkatteFUNN's estimated impact is reduced. On average, however, one krone in forgone tax revenue still increases R&D investment by more than one krone.

To some extent, misuse must be accepted as one of the costs of supporting schemes intended to attract many firms. This is particularly so when, as in the case of SkatteFUNN, control routines and administrative expenditures are kept at a low level. Nevertheless, we argue that it is of great importance to keep a stricter eye on misuse in the future and we recommend several measures to prevent and reduce misuse in chapter 8.

10.3 Minor impact on competition and trade

When assessing the impact of SkatteFUNN on competition and trade, it is important to note that the ef-

fects can be positive as well as negative. SkatteFUNN could distort competition by increasing the market shares of recipients at the expense of other firms (both domestic and international). However, we argue that this increase reduces existing inefficiencies and has a positive impact on competition.

There are several reasons why SkatteFUNN is unlikely to contribute to a net negative impact on trade and competition. We distinguish between domestic and international effects.

Domestically, any government measure may be distortive. This is especially the case if there is a certain degree of selectivity, i.e. if the measure is directed at a specific industry or region to enable it to increase its market share, and thus distorts competition. Market shares can be gained by SkatteFUNN enabling firms to increase the quality of their products (if additionality is high) or reduce their prices (if additionality is low). However, SkatteFUNN is neutral by design. As it is a rights-based scheme, there is no selection bias associated with receiving SkatteFUNN.

SkatteFUNN does, nonetheless, favour SMEs (because of both the more favourable tax rate for SMEs and the cost cap). This is intentional, and arguably has a positive impact on the competitive environment as it reduces entry barriers and counteracts the bias towards large firms inherent in other available R&D schemes.

The fact that we do find a high and positive additionality attributable to SkatteFUNN implies that market shares can be gained by beneficiaries due to increased product quality. Increasing the market shares for SMEs is a positive impact of SkatteFUNN, creating a healthier competitive environment.

Internationally, we find that a relatively small share of the exporting recipients receive aid above the limit of *de minimis aid*. It is also important to note that even if support exceeds this limit, it does not necessarily impact competition and trade. Furthermore, users of SkatteFUNN are found to import more from foreign firms, which might be a positive externality for Norway's trading partners.

However, with the scheme's generosity expanding significantly over the past few years, the potential for affecting competition and trade has risen. Given that a small share of firms utilises the new, higher cost caps, and that the main objective of the scheme is to complement other R&D support schemes through support to relatively small R&D projects, we do not recommend a further increase in the cap.

On balance, we argue that the positive impact outweighs the negative.

10.4 The benefits of SkatteFUNN outweigh the costs

Even if a public support scheme has positive social effects, it will also have social costs. The benefit, i.e. the value-added from increased R&D investment, must be higher than the social cost of the public contribution (the forgone tax revenue), the negative impact on trade and competition and the misuse of the scheme.

We find that a significant part of the private economic gains that are attributable to SkatteFUNN accrues to the recipients in the form of return on their additional R&D investment, streamlining of production processes and further improvement of productivity. For the overall economy, the main economic effect is the increase in productivity through the positive knowledge spillovers and product improvements.

Our estimates of input additionality, in chapter 4, indicate that SkatteFUNN firms invest 2 kroner more in R&D per 1 krone of tax credit they receive. This implies that NOK 1 billion of tax credit results in NOK 2 billion of extra R&D investment (1 billion private investment and 1 billion through SkatteFUNN). Our estimate of the rate of return on additional R&D through SkatteFUNN is 8.2 per cent, which is not significantly different from the rate of return on R&D in general.

At the same time, SkatteFUNN is financed through taxes, which is distortive, meaning that the social costs associated with the public funding exceed the government's direct costs. To adjust for the efficiency loss of tax financing activities, it is common to assume that the social cost is 20 per cent higher than the cost of the scheme. Overall, NOK 1 billion through SkatteFUNN triggers NOK 2 billion of private investment. When we take account of the efficiency loss, we end up with total social costs of NOK 2.2 billion.

If we assume that there is no depreciation of R&D capital, the private sector gain would equal social costs after 14 years. However, it is common in the academic literature to depreciate R&D capital by 15 per cent annually. With this depreciation rate, the annual gain in additional value-added falls very fast. Reaching NOK 1 billion after 16 years the gain is no more than NOK 1.1 billion after 40 years. This amount covers only private investment, while public investment is purely a subsidy for expected positive spillovers from R&D. In accordance with Eurostat recommendations, an even higher rate, of 20 per cent, is applied in the national accounts. In both cases, R&D investment would not be socially profitable without positive spillovers.

To shed further light on the size of private gains from SkatteFUNN, we estimate the depreciation rate of R&D capital that would result in socially profitable R&D investment without positive spillovers. The answer is 7 per cent.

The conclusion as to whether SkatteFUNN is socially profitable or not depends on whether there are positive externalities attributable to R&D investment. The answer is yes if we believe that R&D has strong positive spillovers, and the great majority of publications do,[139] and if the knowledge created has lasting importance. The answer would be no in the opposite case, with weak positive spillovers and rapid depreciation of new knowledge.

10.5 Policy recommendations

We conclude that the SkatteFUNN benefits of positive input and output additionality, external effects and positive impact on competition and trade very likely exceed the costs of negative distortive effects and misuse. This leads us to a clear recommendation to continue SkatteFUNN.

However, we propose several improvements for the scheme, including simplifications and further stimulation of R&D and cooperation. The recommendations are based on our results, and we also keep in mind both total costs and the original intention that SkatteFUNN should be a broad scheme stimulating R&D in many firms. We also suggest several measures for addressing misuse of the scheme, to improve its efficiency and legitimacy.

The policy proposals may be viewed as a menu. Some of the suggestions are extensions that increase the costs of the scheme, others represent a cost reduction. The net effect on forgone tax revenue of all the proposals could be close to neutral,

[139] See e.g. W. J. Baumol (2002) who shows that the possible spillovers may vastly exceed the private gains.

maybe even positive if we take account of the potential for recuperation from audits. See tables 10.1 and 10.2 for calculations of forgone tax revenue.

The following section contains our policy recommendations and a summary of several measures for explicitly addressing misuse of the scheme. We elaborate upon the latter in chapter 8.7. We have also assessed the rationale of implementing a lower limit for project size in SkatteFUNN, but concluded that we do not recommend this, see appendix D for an analysis.

Our policy recommendations are:

1) Reduce the project cost cap: SkatteFUNN was originally designed as a broad scheme to support relatively small R&D projects in the private sector, embracing SMEs as well as large firms. The cap on total project costs has now reached such a high level that it no longer applies to SMEs. Furthermore, we believe that research projects of this magnitude should be subjected to more stringent control procedures before support is granted. Government funding of large projects should be based on competition, because this probably increases the output additionality and reduces the potential for misuse. Such support is already offered by other schemes through IN and RCN. We therefore suggest reducing the total cost cap for combined inhouse and purchased R&D from NOK 50 million to NOK 25 million. The previous annual limit of NOK 25 million for inhouse R&D should remain unchanged, but the increased cap for purchased R&D should be removed. Applicants should be free to choose their preferred mix of inhouse and purchased R&D within the new, lower frame.

2) Increase the tax credit rate for intensive collaboration: Recent years' increases in the cap on the costs of purchased R&D have not succeeded in stimulating collaboration between firms and research institutions, as was intended. The number of collaborative projects has been stable throughout the period of SkatteFUNNs' existence, while the share of collaborative projects has decreased significantly. The proposed reduction suggested in 1) reduces incentives to collaborate, but also significantly reduces the forgone tax revenue. We therefore propose that some of the saved forgone tax revenue be used to reward projects with *intensive collaboration*, defined as projects that spend at least half the budget on purchased R&D. The entire project will then receive increased deductions (i.e., costs related to both purchased and inhouse R&D). We suggest increasing the tax credit rate to 25 per cent for intensive collaboration, in accordance with the rate suggested by NOU 2000: 7.[140] This should stimulate both active collaboration[141] and initiatives for inhouse investment. For reference purposes, table 10.1 also includes calculations for an increase to 40 per cent, which is closer to a typical subsidy rate for RCN schemes.

3) Increase the tax credit rate for firms new to SkatteFUNN: We find that firms new to SkatteFUNN exhibit the highest additionality during the first years in which they use the scheme. We therefore suggest increasing the tax credit rate for firms new to the scheme for the first three years, cf. table 10.2 column 1.[142] For the sake of simplicity, we suggest sticking with the 25 per cent rate suggested in 2).[143] Ideally, this could be restricted to new users that have not invested in R&D in the three years prior to their application, thereby both reducing

[140] NOU 2000: 7 suggested 25 per cent for all firms.
[141] In 2015, the share of purchased R&D from approved institutions was on average about 30 per cent for collaborative projects. Thus, our proposal should create a clear incentive to increase both the number and the scope of collaborative projects.
[142] A stricter option would be to restrict users of all R&D funding agencies, not only users of SkatteFUNN (which could be enabled using Samspillsdatabasen).
[143] By way of comparison, a similar scheme in France grants such firms a 40 per cent tax credit. As shown in table 10.2, an increase from 25 to 40 per cent for new firms could almost quadruple forgone tax revenue from new firms.

costs considerably and increasing expected input additionality, cf. table 10.2 column 2. However, it would be difficult to verify whether firms self-reported information about previous R&D is correct (given that they are not subject to reporting R&D in their financial accounts and not all report to the R&D survey). Differentiating the tax credit rate for intensive collaboration and firms new to SkatteFUNN as suggested in 2) and 3) implies increases in administrative costs. These could be countered by abolishing the existing differentiation between large firms and SMEs as suggested in 4).

4) Abolish the general differentiation of the tax credit rate between large firms and SMEs: The estimated input additionality is similar for SMEs and large firms, and rates of 18 and 20 per cent seem too close to justify the additional administration involved in dividing applicants by firm size. The definition that all firms with less than 250 employees are SMEs has been adopted from larger economies, and is not well suited to Norwegian conditions, where a lower limit would be more appropriate. Our results indicate that the demarcation should rather be based on project size, as smaller projects tend to have higher additionality regardless of firm size, in line with our suggestions 1) and 3). We therefore recommend simplifying the scheme by using the same tax credit rate for all firms (with the new, targeted exemptions for collaboration and new R&D investors suggested in 2) and 3)). Our empirical results do not provide guidance regarding the level of this rate. Based on the current rates, we suggest 20 per cent rather than 18, as the implied increase for large firms would partly compensate for the reduced cap on overall costs proposed in 1.[144]

5) Increase the hourly cost cap: The hourly cost cap on inhouse R&D has been subject to seemingly random changes and under-indexation. Increasing the hourly cost cap could facilitate more extensive use of senior researchers and trigger new research that would not otherwise take place. We suggest increasing it to the net present value of NOK 500 at the time of introduction in 2007. Indexed by wage costs for R&D personnel, this amounts to approximately NOK 700 in 2017.[145] This should be followed up with corresponding annual adjustments. A new hourly wage cost cap of NOK 700 implies that the effective tax credit is 20 per cent for employees with wages of less than NOK 925,000 (assuming a 40 per cent overhead cost and a total wage cost of NOK 1,295,000).[146] For employees with wages higher than NOK 925,000, the effective tax credit will be less than 20 per cent of total wage costs.

6) Make the hourly cost cap applicable to purchased R&D: When purchasing R&D services from other firms, one is not subject to the ceiling for hourly costs and hours spent. This may create an incentive to establish subsidiaries, or to purchase R&D services from other firms in the group, in order to circumvent the cap on the number of hours permitted and the cap on hour costs. We propose introducing the same cap on hourly costs for all R&D. This provides a simplification of the scheme and could reduce misuse and revenue loss.

[144] For reference purposes, according to our estimates, as explained below, if the tax credit rate was increased to 25 per cent for all eligible firms in 2015, it would lead to a 29 per cent increase in revenue loss, i.e. NOK 746 million extra spent on SkatteFUNN. Conversely, if the tax credit rate was reduced to 18 per cent for all eligible firms in 2015, it would lead to a 7 per cent reduction in revenue loss, i.e. NOK 195 million less used on SkatteFUNN, but probably with a considerable negative effect on SME participation.

[145] We have used total wage costs for R&D personnel (table 07963) and total number of full-time equivalents of R&D personnel (table 07964) from Statistics Norway's databank to calculate this index.

[146] This is estimated as follows: given an hourly wage of NOK 700 and a maximum of 1850 hours per employee per year, the maximum wage cost per employee per year is NOK 700*1850 = NOK 1,295,000. With a 20 per cent tax credit, SkatteFUNN will finance up to NOK 259,000. Given that the annual wage is NOK 925,000, the annual wage cost for the firm, including overheads, is NOK 1,295,000, and the 20 per cent tax credit will cover exactly NOK 259,000.

7) Introduce controls and sanctions to prevent and limit misuse: Both the RCN and the Tax authorities should increase their inspection activity. The firms inspected should be selected on the basis of a combination of risk-based models and randomisation. Random selection of firms will make the scheme easier to evaluate and have a deterrent effect. Audits would in their turn improve the legitimacy of SkatteFUNN. To increase the efficiency of inspections and eliminate possible undesirable behaviour, we also suggest that SkatteFUNN be limited to firms that have their main R&D activity in Norway, i.e. excluding foreign firms with limited tax liability under the Norwegian Tax Act.[147] The inspections could be at least partly self-financed, both by reducing public expenses for the scheme through a fee to be paid by misusing firms. Sanctions could include reclaiming the incorrect tax credit retroactively, imposing additional punitive taxes and normal penal sanctions such as fines or prison punishment. Another possible sanction is to bar firms that misuse the tax incentive from claiming it for some years.

Estimated impact of the recommendations

Some simple calculations of the public cost of the individual recommendations are presented in tables 10.1 and 10.2. It should be borne in mind that we do not know the scope of the behavioural response to the suggested changes, although we may guesstimate the sign. For example, reducing the cost cap to NOK 25 million for all projects will reduce costs directly through reduced support for the largest R&D projects, but could also lead to a reduction in applications, see table 10.1. Likewise, increasing support for collaboration between firms and research institutions might lead to increased collaboration, as intended, while our calculations just include the increased support for existing collaboration; see table 10.1. Nevertheless, the calculations should provide useful information on the scope of the recommendations.

Table 10.1 Overview of changes in forgone tax revenues: stimulation of collaboration

	1) The same project cost cap for collaborative projects		2) Alt.1: 25 per cent deduction for intensive cooperation*		2) Alt. 2: 40 per cent deduction for intensive cooperation*	
Year	In per cent	In millions of NOK	In per cent	In millions of NOK	In per cent	In millions of NOK
2007	-16.8 %	-152	1.5 %	13	5.4 %	49
2008	-18.6 %	-157	1.7 %	14	5.9 %	50
2009	-14.6 %	-147	1.6 %	16	5.7 %	57
2010	-14.8 %	-168	1.4 %	16	5.0 %	57
2011	-14.5 %	-171	1.3 %	15	4.7 %	55
2012	-14.9 %	-197	1.1 %	15	4.1 %	54
2013	-15.6 %	-226	1.3 %	19	4.8 %	69
2014	-9.3 %	-181	1.1 %	21	3.9 %	76
2015	-7.2 %	-187	0.8 %	21	2.9 %	75

Source: Samfunnsøkonomisk analyse AS

Note: All calculations are based on the realised behaviour of SkatteFUNN users and do not consider the potential behavioural response to the proposed changes. * 'Intensive collaboration' is when at least half of the project costs are purchased R&D from an approved R&D institution. In that case, the whole project gets a higher deduction rate, i.e. including inhouse R&D.

[147] See Tax Act § 2–3.

Table 10.2 Overview of changes in forgone tax revenues: stimulation of R&D investment and participation in the scheme

	3) Alt.1: 25 per cent deduction for new SkatteFUNN users**		3) Alt.2: 25 per cent deduction for new SkatteFUNN users with no R&D in last 3 years**		4) 20 per cent deduction for all firms		5) Indexed hourly cost cap*	
Year	In per cent	In millions of NOK	In per cent	In millions of NOK	In per cent	In millions of NOK	In per cent	In millions of NOK
2007	11.0 %	100	2.1 %	19	2.1 %	19	0 %	0
2008	10.7 %	90	1.8 %	15	2.1 %	18	1.2 %	10
2009	10.3 %	103	1.1 %	11	2.4 %	24	3.6 %	36
2010	9.7 %	110	1.4 %	16	2.3 %	26	4.4 %	50
2011	9.6 %	113	1.5 %	18	2.1 %	24	3.4 %	40
2012	9.9 %	131	1.5 %	19	2.1 %	28	4.3 %	56
2013	9.8 %	141	1.7 %	24	2.2 %	32	4.8 %	69
2014	9.5 %	185	1.7 %	33	2.4 %	47	2.5 %	49
2015	8.8 %	230	1.3 %	34	2.8 %	74	4.4 %	115

Source: Samfunnsøkonomisk analyse AS

Note: All calculations are based on the realised behaviour of SkatteFUNN users and do not consider the potential behavioural response to the proposed changes. * Personnel hourly costs are adjusted from NOK 500 in 2007 by the index for R&D personnel wage costs (only for projects with total costs lower than the cap). ** Estimated for the first 3 years of SkatteFUNN use (based on the average project length).

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Appendix A – Survey of beneficiaries

A.1 Web survey

In April 2017, there were 38,853 projects in the SkatteFUNN project database. In order to select a sample representative of the entire population of SkatteFUNN projects, we went through a series of steps to eliminate projects (and thereby potential contacts) that were not deemed relevant to include in the user survey. In short, this process included elimination of:

- Inactive firms
- Projects without e-mail address to project leader
- Projects that are not completed
- Projects that are not approved
- Projects with missing firm NACE code
- Projects with missing number of firm employees
- All projects bar the most recently completed for each firm
- Firms missing year of establishment (or nonsense years)
- Projects starting before 2010
- Projects ending after 2016

The elimination steps are listed in Table A.1 in the order they were executed. First, we eliminated the 10,453 projects conducted by the 4,755 firms that were no longer active. The next step was to exclude 4,628 projects that lacked e-mail address to the project leader. All 8,381 projects that were listed as on-going or not approved were then excluded, as were 447 projects where information on firm's NACE code, number of employees or year of establishment were missing.

For the remaining firms that had completed more than one SkatteFUNN project, we eliminated all but the most recently completed project, resulting in elimination of 8,976 projects. We did this for a number of reasons. Firstly, to ensure that we only had one project per firm in our sample. Secondly, by choosing the most recent project, we maximised the chances of including the most up-to-date e-mail address. Lastly, we assumed that it would be most intuitive for respondents to answer based on their experiences from the most recent project (in some questions we asked for their compound experiences).

The last elimination step was to remove the 1,721 projects that had started before 2010 and those ending after 2016. The reasoning being that the dropout for projects older than seven years would likely be significant (due to outdated email addresses and lack of engagement, or recollection, from respondents), and that projects which ended less than a year ago likely would not give a fair picture of the results and impact that SkatteFUNN projects contribute to. These eliminations resulted in a population of 4,247 firms (and an equal number of SkatteFUNN projects).

Table A.1 Elimination steps

	Projects eliminated	Remaining projects
Original number of projects		38,853
Elimination of inactive firms	10,453	28,400
Elimination of projects without e-mail address to project leader	4,628	23,772
Elimination of projects not completed	3,258	20,514
Elimination of projects not approved	5,123	15,391
Elimination of projects with missing NACE code	2	15,389
Elimination of projects with missing number of employees	13	15,376
Elimination of all projects but the most recent for each firm	8,976	6,400
Elimination of firms missing year of establishment (or nonsense years)	432	5,968
Elimination of projects starting before 2010	1,643	4,325
Elimination of projects ending after 2016	78	4,247

Source: Technopolis analysis of SkatteFUNN Project database

From the population of 4,247 firms, a sample of 1,500 firms were randomly selected to be invited to respond to the survey. The survey invitations were sent out on 25 April 2017. Non-respondents were reminded on four occasions whereupon the survey closed on 7 June 2017. Some of the 1,500 e-mail addresses turned out to be inactive or incorrect, and while we made efforts to locate present addresses, in the end 241 invitations did not reach their intended contact.

The survey resulted in a grand total of 600 responses, which corresponds to a response rate of 40 per cent. The distribution of the responses, non-responses and response rate across private sectors and number of employees is listed in Table A11.2. The survey was conducted in Norwegian.

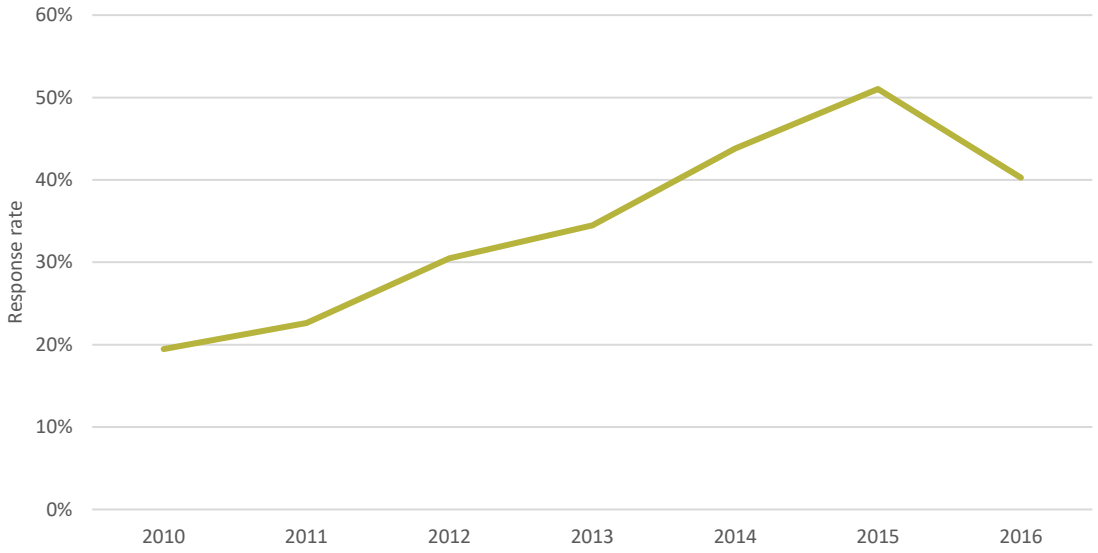
Table A11.2 Distribution of population and firms on selected strata

	Private sector				Number of employees					Total
	Manu-facturing (NACE C)	ICT (NACE J)	Pro., sci., and tech. activities (NACE M)	Other	–4	5–9	10–19	20–49	50–	
Population	357	357	358	428	542	264	224	240	230	1,500
No contact	62	58	46	75	82	38	28	43	50	241
Non-re-sponses	151	152	155	201	241	110	90	116	102	659
Responses	144	147	157	152	219	116	106	81	78	600
Response rate	40%	41%	44%	35%	40%	44%	47%	36%	34%	40%

Source: Technopolis analysis of SkatteFUNN project database and Technopolis' user survey

As expected, there is a time effect in the propensity to respond, see Figure A.1. There is an almost linear correlation between the number of years since the project ended and the response rate until 2015, with an inexplicable drop in 2016. For projects that ended in 2010 the response rate was 20 per cent, compared to 50 per cent for projects that ended in 2015.

Figure A.1 Response rate per end year of last project

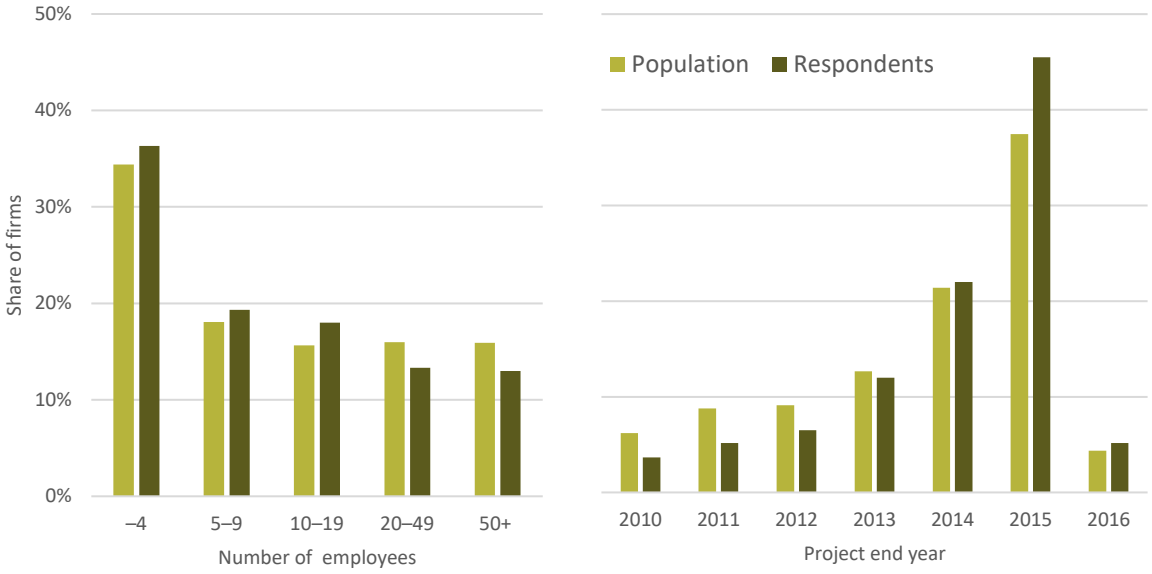


Source: Technopolis' user survey

The firms constitute fairly accurate reflection of the original population. Figure A.2 compares the firms with the original population in terms of number of employees and end year of the most recent project. There are only small differences in terms of number of employees, there is a slight bias towards newer projects (ending in 2014–2016), a consequence of the lower response rate for older projects.

The low number of projects in the original population in annual years is the result of the elimination of all but the latest project for firms that have had more than one, and the low number in 2016 is due to many projects in the SkatteFUNN project database not yet being completed.

Figure A.2 Distribution of original population and responding firms by number of employees and year of completion of latest project.



Source: Technopolis analysis of SkatteFUNN project database and Technopolis' user survey

If we compare the responding firms and the original population in terms of repeat use of SkatteFUNN, we find that the responding firms on average have had more SkatteFUNN projects than the original population, see Table A.3. The median is at 3 projects also higher among responding firms than the 2 projects for the original population.

This pattern is further confirmed by close to every other firm in the original population having only one SkatteFUNN project compared to a quarter of the responding firms. In conclusion, the group of responding firms is a reasonably accurate (but not perfect) sample of the original population, with a slight bias towards firms with more recent projects and a larger use of SkatteFUNN.

Table A.3 Analysis of number of projects per firm

Number of projects	Original population	Responding firms
Average	2.8	4.3
Median	2	3
Share with 1 project only	49.7%	25.7%

Source: Technopolis analysis of SkatteFUNN project database and Technopolis' user survey

User survey tables

All tables with questions, answer alternatives and number of responses are available at www.SØA.no.

A.2 Interviews

We have also conducted 50 interviews to complement the survey. The bulk of the interviews were made with firms that have had SkatteFUNN project(s). The selection was made from the population of 4,247 firms described above but excluding the survey population. The selection of interviewees was strategic, and we sought to obtain a mix of small and large firms that represented different sector and numbers of completed SkatteFUNN projects. This strategic approach was nevertheless hampered by a low propensity to agree to be interviewed, which introduced a significant level of "self-selection" among interviewees.

The interviews employed a semi-structured interview guide that allowed the interviewer to adapt questions to the interviewee's level of experience of SkatteFUNN, but still systematically pose a set of predetermined questions. The telephone interviews were conducted in Norwegian[148] in the period of May to August 2017. In addition, we conducted a handful of complementary interviews with national stakeholders, including the RCN, Innovation Norway, the Industrial Development Corporation of Norway (Siva), the Confederation of Norwegian Enterprises (NHO), the Federation of Norwegian Industries and the Association of Norwegian Research Institutes (Forskningsinstituttenes fellesarena, FFA), to complete the interpretation and analysis of survey results and the interviews with SkatteFUNN beneficiaries. We also (unsuccessfully) sought to interview The Norwegian Association of Higher Education Institutions.

[148] Interviewees spoke Norwegian whereas interviewers spoke Norwegian or Swedish (depending on who conducted the interview); the languages are close enough to be mutually intelligible.

Appendix B – Data sources

Accounting statistics: In the accounting statistics from Statistics Norway, a firm is defined as 'the smallest legal unit comprising all economic activities engaged in by one and the same owner'. It corresponds in general to the concept of a firm. A firm can consist of one or more establishments that are the geographically local units conducting economic activity within an industry class. Another unit is the consolidated group, which consists of a parent firm and one or more subsidiaries. Both the parent firm and the subsidiaries are firms as defined here. All joint-stock firms in Norway are obliged to publish firm accounts every year. The accounts statistics contain information obtained from the income statements and balance sheets of joint-stock firms, and, in particular, information about operating revenues, operating costs and operating profit/loss, labour costs, and the book values of the firm's tangible fixed assets at the end of a year, their depreciation and write-downs.

R&D statistics: The R&D statistics are survey data collected by Statistics Norway every second year up to 2001, and annually after that. These data comprise detailed information about firms' R&D activities, i.e. total R&D expenses divided between own R&D and purchased R&D services, the number of employees engaged in R&D activities and the number of full-time equivalents worked in R&D. The 2001, 2004, 2006, 2008, 2010 and 2012 editions are combined with the Community Innovation Survey (CIS) and contain information on whether firms have introduced different types of innovation over the three-year period preceding each survey. Information on several types of innovation protection including patent applications, trademarks, design and copyright is also provided in CIS and used in the analysis. Since 2014 the R&D survey and the CIS are conducted separately. In each wave, the sample is selected using a stratified sampling method for firms with 10–50 employees, whereas all firms with more than 50 employees are included. The strata are based on industry and firm size. Each survey contains about 5 000 firms (6 000 in the most recent surveys), although not all of them provide complete information.

The Register of Employers and Employees (REE): This register from Statistics Norway contains information about each individual employee's contract start and end, wages and contract working hours. Since both the firm identification number and the personal identification number are included, these data can easily be aggregated to the firm level.

The National Education Database: This database from Statistics Norway includes individually based statistics on education and contains a six-digit number, where the leading digit describes the educational level of the person. We use this data set to obtain information on the length of education of employees. This information was first integrated into a common data base with REE and then aggregated to the firm level.

SkatteFUNN project database: This is the Research Council of Norway's database that contains information on all SkatteFUNN projects' applications, i.e. who is the project leader (with firm identification number), the budgeted cost by item (personal cost, purchased R&D from an approved R&D institution, equipment, other costs), start and the end of the project, collaborative partners, description of the main goal, etc. Both approved and not approved projects are registered in this database.

Tax register: This is the Norwegian Tax Administration's database on all SkatteFUNN beneficiaries. This database contains information on the amount of R&D expenditures eligible for the tax credit in the given

year, the applied deduction rate (i.e. 18 or 20 per cent), the total amount of tax credit obtained and the amount that was paid in cash.

Database for public support schemes: This is Samfunnsøkonomisk analyse AS's database established for the Ministry of Trade, Industry and Fisheries. The database is a compilation of project data from 16 public funding agencies. All observations are categorized according to the type of support that has been given (grant, loan, equity investment, etc.) and what kind of activity is supported. This allows for comparisons across funding agencies. Per 2018 the database contains 649,749 beneficiary-year observations, from the following agencies:

- Argentum (2001-2016)
- Export Credit Norway (2011-2016)
- Enova (2002-2016)
- EU's Seventh Framwork Programme (2007-2016)
- The Norwegian Seafood Research Fund (2001-2016)
- County municipalities (2007-2016)
- Giek (2011-2016)
- Horizon 2020 (2016)
- Innovation Norway (2000-2016)
- Investinor (2009-2016)
- Research Council of Norway (2000-2016)
- Norwegian Space Center (2014-2016)
- Regional Research Funds (2010-2016)
- Siva (2009-2016)
- SkatteFUNN (2002-2016)
- Seed Capital Funds (1998-2016)

Public funding schemes that support R&D and innovation and are relevant for our analysis are from the Research Council, EU FP7, Horizon 2020, Innovation Norway, Regional Research Funds, Enova, Norwegian Space Centre and R&D support from county municipalities.

Appendix C – Various results

Table C1. Test of common trend assumption for SkatteFUNN beneficiaries and non-beneficiaries by user generation, the entire sample

Pre-reform period	G02-03		G04-06		G07-08		G09-10		G11-13		G14-15	
	Coef. α	Std. Er.	Coef. α	Std. Er.	Coef. α	Std. Er.	Coef. α	Std. Er.	Coef. α	Std. Er.	Coef. α	Std. Er.
2000	0.06	0.19	0.31	0.34	-0.01	0.99	1.34	1.05	-0.35	0.78	0.87	0.66
2001	0.62 ***	0.23	1.36 ***	0.45	0.32	1.14	0.27	1.37	0.56	1.08	0.62	1.03
2002			1.13 **	0.45	0.73	1.23	0.36	1.39	2.26 **	1.14	0.24	1.02
2003			2.80 ***	0.44	0.80	1.12	-0.47	1.29	1.83 *	1.03	-0.64	0.93
2004					2.01 *	1.09	0.06	1.21	1.51	0.99	0.09	0.95
2005					2.39 **	1.07	0.02	1.21	1.86 *	1.06	0.49	0.96
2006					3.02 ***	1.06	2.45 **	1.15	2.03 **	0.96	-0.52	0.90
2007							2.42 **	1.15	1.49	0.92	-0.14	0.94
2008							2.72 **	1.15	2.81 ***	0.86	-0.39	0.94
2009									3.47 ***	0.85	-0.46	0.97
2010									4.64 ***	0.82	-0.28	0.92
2011											1.34	0.98
2012											2.99 ***	0.97
2013											3.75 ***	0.95

Note: The reported coefficients α are from the model (3) of chapter 4.4. Each coefficient shows whether R&D expenditures developed differently among the corresponding generation of SkatteFUNN beneficiaries compared to non-beneficiaries in the given pre-reform year.

Table C2. Test of common trend assumption for SkatteFUNN beneficiaries and non-beneficiaries by user generation, the sample after matching with R&D experience

Generation	Pre-reform period	Coef. α	Std. Er.	t	P>|t|
G02-03	2000	-0.156	0.198	-0.79	0.431
	2001	0.113	0.234	0.48	0.630
G04-06	2001	-0.276	0.328	-0.84	0.401
	2002	-0.430	0.363	-1.18	0.238
	2003	0.029	0.377	0.08	0.938
G07-08	2004	0.472	0.498	0.95	0.344
	2005	-0.035	0.501	-0.07	0.944
	2006	-0.072	0.522	-0.14	0.890
G09-10	2006	-0.042	0.515	-0.08	0.934
	2007	0.163	0.553	0.29	0.769
	2008	0.492	0.595	0.83	0.409
G11-13	2008	0.083	0.337	0.25	0.807
	2009	-0.451	0.335	-1.35	0.179
	2010	-0.153	0.340	-0.45	0.654
G14-15	2011	0.324	0.574	0.56	0.573
	2012	0.231	0.599	0.39	0.700
	2013	0.385	0.604	0.64	0.525

Note: The reported coefficients α are from the model (3) of chapter 4.4. Each coefficient shows whether R&D expenditures developed differently among the corresponding generation of SkatteFUNN beneficiaries compared to non-beneficiaries in the given pre-reform year.

Table C3: Results for the main model in chapter 4.4 with and without including firms with other types of public support

	(1) Coef.		Std. Er.	(2) Coef.		Std. Er.
user1xperiod1xtreat	0.538	***	0.060	0.530	***	0.062
user1xperiod2xtreat	0.506	***	0.057	0.512	***	0.059
user1xperiod3xtreat	0.299	***	0.077	0.272	***	0.082
user1xperiod4xtreat	0.330	***	0.082	0.355	***	0.090
user1xperiod5xtreat	0.380	***	0.075	0.368	***	0.081
user1xperiod6xtreat	0.452	***	0.097	0.490	***	0.104
user2xperiod2xtreat	0.487	***	0.060	0.496	***	0.062
user2xperiod3xtreat	0.376	***	0.083	0.388	***	0.084
user2xperiod4xtreat	0.307	***	0.104	0.317	***	0.106
user2xperiod5xtreat	0.243	**	0.115	0.204	*	0.120
user2xperiod6xtreat	0.403	***	0.125	0.373	***	0.132
user3xperiod3xtreat	0.378	***	0.094	0.411	***	0.095
user3xperiod4xtreat	0.151		0.103	0.168		0.104
user3xperiod5xtreat	0.103		0.134	0.078		0.135
user3xperiod6xtreat	0.328	**	0.143	0.344	**	0.146
user4xperiod4xtreat	0.553	***	0.093	0.540	***	0.093
user4xperiod5xtreat	0.329	***	0.109	0.274	**	0.107
user4xperiod6xtreat	0.496	***	0.146	0.422	***	0.146
user5xperiod5xtreat	0.201	***	0.076	0.180	**	0.076
user5xperiod6xtreat	0.362	***	0.091	0.344	***	0.092
user6xperiod6xtreat	0.329	***	0.086	0.334	***	0.086
Employees (log)	0.209	***	0.031	0.212	***	0.032
Employees (log)^2	0.007		0.007	0.007		0.007
Share of high-skilled	0.154	***	0.048	0.135	***	0.049
Other public support (log)	0.021	***	0.008			
Financial liquidity rate (log)	-0.009		0.012	-0.013		0.012
Tax position (d)	-0.100	***	0.022	-0.098	***	0.022
R&D experience (d)	0.224	***	0.024	0.227	***	0.024
Mining & quarrying (d)	0.428		0.428	0.458		0.429
Tech. manufacturing (d)	0.188	**	0.079	0.191	**	0.080
Other manufacturing (d)	0.014		0.088	0.029		0.090
Construction (d)	-0.018		0.122	-0.008		0.122
Retail trade (d)	0.278	***	0.089	0.286	***	0.089
Transport (d)	0.761	***	0.271	0.772	***	0.268
Tourism (d)	-0.275		0.340	-0.256		0.339
Media (d)	0.375	***	0.096	0.399	***	0.096
ICT (d)	0.373	***	0.076	0.403	***	0.076
Professional and scientific activities (d)	0.132		0.087	0.124		0.088
Tech. services (d)	0.202	**	0.083	0.212	**	0.083
Business-oriented services (d)	0.310	***	0.120	0.328	***	0.119
Education (d)	0.583	***	0.199	0.606	***	0.200

Table C3 cont.: Results for the main model in chapter 4.4 with and without including firms with other types of public support

Health (d)	-0.273		0.239	-0.255		0.242
Other service activities (d)	-0.194		0.136	-0.180		0.137
East-Norway (d)	-0.297	***	0.049	-0.296	***	0.049
South (d)	-0.303	***	0.052	-0.295	***	0.053
West (d)	-0.218	***	0.054	-0.216	***	0.054
Mid-Norway (d)	-0.272	***	0.078	-0.255	***	0.078
North (d)	-0.230	***	0.089	-0.204	**	0.090
Constant	5.929	***	0.467	5.749	***	0.467
No. of obs.	13992			13344		
No. of firms	3402			3325		
R^2	0.189			0.180		

Table C4 "Bang for the buck": alternative model (after matching without controlling for the past R&D experience)

Regime	All generations	G02-03	G04-06	G07-08	G09-10	G11-13	G14-15
R02-03	2.28	2.28					
R04-06	2.67	2.72	2.57				
R07-08	2.46	2.53	2.67	1.75			
R09-10	1.99	1.78	2.59	1.37	1.99		
R11-13	1.60	1.76	2.51	1.40	1.31	1.06	
R14-15	1.86	2.45	2.44	1.87	2.02	1.66	1.19
Total	2.16	2.36	2.58	1.55	1.68	1.30	1.19
For firms with past R&D>0	2.17	2.32	2.53	1.55	1.79	1.52	1.46

Appendix D – Assessing the rationale of implementing a lower limit in SkatteFUNN

The main rationale for having a minimum threshold for project size is to reduce costs related to administration and compliance. So far, only Australia has such a threshold. The firms there must incur R&D expenses of at least AUD 20,000 to be eligible for tax credit (that corresponds to approximately NOK 120,000). In New Zealand it was recently suggested to implement a minimum of NZD 100,000 spent on eligible R&D expenditure within one year to qualify for the R&D tax incentive (that corresponds to approximately NOK 560,000), cf. chapter 3.2. The argument for setting the minimum at NZD 100,000 of eligible expenditure is mainly to filter out claims that are not likely to be genuine R&D and to reduce the administrative costs of the scheme. An additional argument is that a lower limit might enhance collaboration between firms, as the cost of the project may be too large for a single firm.

It is then naturally to ask, whether Norway should implement such a lower limit, and if yes, at what level?

To answer this question, we have investigated what the potential benefits and costs of small R&D projects are. Our estimates for input additionality (BFTB) for various amounts of tax credit show that the firms with the smallest projects have the highest BFTB, see table 4.16. Contrary, a recent study of various R&D supporting schemes and their impact on firm performance find that the effect of SkatteFUNN is increasing with the amount of support (Nilsen et al., 2018).[149] However, they provide evidence that small SkatteFUNN projects do have positive and significant effects on value added and labour productivity (with some varying results for sales and number of employees). Overall, we conclude that small projects do lead to additional R&D and improving labour productivity.

Furthermore, we estimate the level where benefits from the R&D project exceed the total costs related to the writing, inspecting and auditing it. To calculate benefits of the project we apply an estimate of additional R&D for the given size of project, e.g. for small projects with total costs equal to NOK 100,000 or less our estimate of BFTB is equal 5. For larger projects, we apply BFTB 2015-estimates from table 4.16. The cost per project is the estimated administrative costs for 2015 (cf. chapter 2.5) divided by the number of applications. In addition, the project specific tax relief is multiplied by 1.2 to get projects specific tax expenses. This part of cost depends on the size of the project.

As the table to the right show, the benefits from a project exceeds public costs already at NOK 20,000 and exceeds total costs at NOK 50,000. The smallest project size that applied for SkatteFUNN in 2015 had total cost equal to NOK 31,000 and the smallest approved project in 2015 had total cost equal to NOK 68,000. Only 1 project had total cost less than NOK 50,000 and 5 projects had total cost less than NOK 100,000 in 2015 implying no any real cut in public administrative costs by introducing these limits.

Cost benefit analysis

Project size	Additional R&D	Public costs	Total costs
10,000	10,000	10,461	37,683
20,000	20,000	12,861	40,083
30,000	30,000	15,261	42,483
40,000	40,000	17,661	44,883
50,000	50,000	20,061	47,283
60,000	60,000	22,461	49,683
70,000	70,000	24,861	52,083
80,000	80,000	27,261	54,483
90,000	90,000	29,661	56,883
100,000	100,000	32,061	59,283
500,000	451,000	128,061	155,283
1,000,000	542,000	138,141	165,363

[149] The effect of SkatteFUNN is found to be lowest if the project support is lower than NOK 0.5 million and highest if the project support is higher than NOK 1.5 million.

To save administrative costs, a much higher limit than NOK 100,000 should be implemented. For example, limiting SkatteFUNN to projects with total R&D costs over NOK 1 million would cut number of applications by 12 per cent, number of SkatteFUNN recipients by 10 per cent and reduce the revenue loss by around NOK 31 million and other public costs by NOK 4 million in 2015. This cut would imply a reduction in the total public costs by only 1 per cent in 2015.

At the same time these projects have contributed with about NOK 117 million in additional R&D (if we apply our estimates for BFTB, cf. chapter 4), which is much higher than saved public costs. All in all, we do not recommend introducing the lower limit.

SAMFUNNSØKONOMISK ANALYSE

BORGGATA 2B
N-0650 OSLO
TLF.: +47 970 43 859
POST@SAMFUNNSOKONOMISK-ANALYSE.NO
ORG.NR.: 911 737 752