Torbjørn Hægeland and Jarle Møen

Input additionality in the Norwegian R&D tax credit scheme

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Abstract

Torbjørn Hægeland and Jarle Møen

Input additionality in the Norwegian R&D tax credit scheme

Reports 2007/47 • Statistics Norway 2007

Tax incentives have become an increasingly popular policy tool over the last decades. Norway introduced an R&D tax credit scheme, called SkatteFUNN, in 2002. The degree of input additionality, i.e. to what extent the scheme induces firms to invest more in R&D than they otherwise would have done, is critical when evaluating the overall efficiency of the scheme. Identifying this effect in a non-experimental setting, where access to the scheme is in principle universal, is demanding. We discuss in detail the identification problems involved. Using a difference-in-difference regression approach, comparing growth in R&D investments for firms above and below the 4 million tax credit cap, our findings suggest that the Norwegian R&D tax credit scheme has stimulated firms to increase their R&D investments. The estimated effect seems to be driven by firms that did very little R&D prior to the introduction of the tax credit scheme was introduced. The size of the effect is hard to assess with any precision, but the scheme seems to induce about two kroner additional R&D per krone spent as tax subsidy.

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Contents

Summary in Norwegian

Et hovedformål med SkatteFUNN-ordningen er at den skal bidra til å øke FoU-investeringene i næringslivet. I en evaluering av ordningen veier derfor spørsmålet om *innsatsaddisjonalitet* tungt. Det er en nødvendig betingelse for at SkatteFUNN-ordningen skal kunne betegnes som en suksess at den fører til at foretakene faktisk utfører mer FoU enn de ville ha gjort i fravær av ordningen. Hvis ikke SkatteFUNN utløser mer FoU, hjelper det for eksempel lite at ordningen administreres på en effektiv og oversiktlig måte.

Vi skal besvare et tilsynelatende enkelt spørsmål: Har innføringen av SkatteFUNN ført til at FoU-investeringene i næringslivet har økt? Når man skal besvare et slikt spørsmål, støter man raskt på store metodologiske utfordringer. For å finne ut hvor mye SkatteFUNN har bidratt til å øke foretakenes FoU-investeringer, må vi gjennomføre en kontrafaktisk analyse. Vi må sammenligne det faktiske nivået på FoU-investeringene med det nivået som ville ha blitt realisert i fravær av SkatteFUNN-ordningen. Ideelt sett bør et slikt spørsmål besvares ved bruk av et kontrollert eksperiment. Man ville da ha delt foretakspopulasjonen i to tilfeldige grupper, hvorav den ene fikk tilbud om skattefradrag for FoU-investeringer, mens den andre var en kontrollgruppe. Dette er imidlertid ikke mulig. SkatteFUNN-ordningen er ikke et kontrollert eksperiment, men en ordning som gjelder for alle foretak. Utfordringen i en ikke-eksperimentell situasjon er å utlede fra historiske data hva som ville vært situasjonen uten innføringen av SkatteFUNN. Generelt sett har man ingen garanti for at historiske data kan avsløre hva som ville ha skjedd under et annet politikkregime.

En innfallsvinkel man kunne tenke seg å benytte, er en sammenlikning av utviklingen i FoU-investeringer for de foretakene som benytter seg av SkatteFUNN-ordningen med utviklingen for de som ikke gjør det. En slik tilnærming vil imidlertid være langt fra idealet om at behandlings- og kontrollgruppen skal være tilfeldig trukne. Det er høyst sannsynlig at de som har gode forskningsideer og dermed ser muligheter for profitable FoU-investeringer, i større grad vil benytte ordningen enn de som ikke har det. I en slik situasjon er det ikke mulig å bruke FoU-investeringene til foretak som ikke benytter seg av SkatteFUNN-ordningen som et anslag på hva FoU-investeringene i SkatteFUNN-foretak ville vært i fravær av ordningen.

Vår foretrukne strategi for å identifisere effekten av SkatteFUNN, er å benytte oss av en såkalt "diskontinuitet" som er innebygd i ordningen. Skattefradrag for FoU gjennom SkatteFUNN er begrenset til investeringer på inntil 4 millioner kroner for egenutført FoU og inntil 8 millioner kroner hvis det er samarbeidsprosjekter med en godkjent FoU-institusjon. Foretak som ville ha investert mer enn disse beløpsgrensene i fravær av SkatteFUNN, får ikke noe direkte insentiv gjennom SkatteFUNN til å øke sine FoU-investeringene. Det marginale FoU-prosjektet deres får ikke redusert sin pris. (Disse foretakene har selvsagt insentiv til å søke SkatteFUNN for de prosjektene de ville ha gjennomført uansett). Foretak som ville ha investert mindre enn beløpsgrensene, har derimot et insentiv til å øke sine investeringer som følge av SkatteFUNN, siden SkatteFUNN gjør deres marginale FoU-prosjekt billigere. De får et subsidium på 18 eller 20 øre av hver ekstra krone de investerer i FoU opp til beløpsgrensen. Dette vil antakelig føre til at noen prosjekter som ville blitt ansett for å være bedriftsøkonomisk ulønnsomme i fravær av SkatteFUNN, nå anses som bedriftsøkonomisk lønnsomme. Det er mulig å anta at hvorvidt et foretak ville ha investert mer eller mindre enn beløpsgrensen i fravær av SkatteFUNN til en viss grad er tilfeldig. Vår hovedstrategi for å identifisere effekten av SkatteFUNN er derfor å sammenlikne veksten i FoU-investeringer for de to gruppene av foretak og *anta* at forskjellen kan tilskrives at den ene gruppen er subsidiert på marginen mens den andre ikke er det. Vi antar altså at foretakenes *vekst* i FoU-investeringer i fravær av SkatteFUNN ikke er systematisk relatert til om de ville ha investert over eller under beløpsgrensen. Dette er ikke en triviell forutsetning. Det er ikke åpenbart at foretak med små og store FoU-investeringer har den samme forventede vekstraten i fravær av ordningen. Hvis det i tillegg er slik at FoU-investeringene for hvert enkelt foretak tenderer til å variere rundt et "typisk" nivå, vil observerte vekstrater kunne være influert av såkalt

"regression to the mean". Dette innebærer at foretak som et år har et uvanlig høyt investeringsnivå, vil ha større sannsynlighet for å bli klassifisert som "over beløpsgrensen", samtidig som de trolig vil redusere FoU-investeringene i neste periode, og motsatt. For å redusere dette problemet, klassifiserer vi foretak som over eller under beløpsgrensen basert på all tilgjengelig historisk informasjon om deres FoU-investeringer før SkatteFUNN ble innført.

I hoveddelen av våre analyser er to-gruppesammenlikningen beskrevet ovenfor inkorporert i et regresjonsrammeverk. Dette har flere fordeler. For det første kan vi inkludere flere kontrollvariable. Dette øker sammenliknbarheten mellom de to gruppene, ved at vi kontrollerer for systematiske forskjeller i observerte faktorer som også påvirker FoU-investeringene. For det andre kan vi benytte alle tilgjengelige observasjoner på en systematisk måte, ikke bare én observasjon før og én etter at ordningen ble innført. I tillegg kan vi ved å bruke et regresjonsrammeverk besvare mer spesifikke spørsmål, f.eks. hvorvidt effektene er forskjellige på kort og lang sikt, eller om spesielle foretakskjennetegn er assosiert med høy eller lav addisjonalitet. Det er likevel verd å understreke at de utfordringene vi har drøftet ovenfor knyttet til identifikasjon av effekten av SkatteFUNN-ordningen ikke kan løses ved en regresjonsteknikk i seg selv.

Vår hovedanalyse tar utgangspunkt i SSBs FoU-undersøkelse. Denne datakilden har sine åpenbare fordeler, blant annet at den også omfatter foretak som aldri har søkt SkatteFUNN, at opplysningene om FoU er gitt i en sammenheng som i utgangspunktet ikke har noe som helst med SkatteFUNN-ordningen å gjøre, og at opplysningene går tilbake til lenge før SkatteFUNN ble innført. Et problem ved bruk av denne datakilden er imidlertid at en vesentlig del av SkatteFUNN-foretakene og SkatteFUNN-prosjektene faller utenfor analysen, siden FoU-undersøkelsen omfatter foretak med minst 10 ansatte, og en stor andel av SkatteFUNN-midlene, både målt i skattefradrag/tilskudd og i antall prosjekter, faktisk går til små foretak. Funn fra analysen basert på FoU-statistikken, kan ikke uten videre generaliseres til de mindre foretakene, selv om mange av de samme insentivene og beslutningsmekanismene nok også gjør seg gjeldende for disse. Vi benytter derfor også data fra SkatteFUNN-databasen. Denne er i utgangspunktet mindre egnet, men gir informasjon om alle søkere. Resultatene basert på denne datakilden samsvarer godt med det vi finner ved bruk av data fra FoU-undersøkelsen.

Siden et av målene med SkatteFUNN-ordningen er å øke FoU-investeringene gjennom å stimulere flere foretak til å drive med FoU, er det fra et evalueringsmessig synspunkt uheldig å utelate foretak som aldri før har gjort FoU fra utvalget. Vi velger imidlertid å se på disse foretakene i en separat analyse, siden beslutningen om å investere i FoU for første gang kan være en ganske annerledes enn beslutningen om å endre nivået på FoU-investeringene.

Gjennom analyse av data på foretaksnivå finner vi at foretak som har mottatt støtte gjennom SkatteFUNN har sterkere vekst i sine FoU-investeringer enn andre foretak. En medvirkende årsak til dette resultatet er trolig at foretak med gode forskningsideer selvselekterer seg inn i ordningen. Vår hovedstrategi for å løse dette problemet er forklart ovenfor, og våre viktigste funn kan oppsummeres slik:

- Foretak som tidligere investerte mindre enn beløpsgrensen for fradrag har økt sine FoU-investeringer mer enn foretak som tidligere lå over beløpsgrensen og dermed ikke fikk et direkte insentiv til å øke sine investeringer gjennom SkatteFUNN.
- De økte FoU-investeringene til foretak under beløpsgrensen reflekterer ikke bare økt rapportert FoU, men viser seg også ved at arbeidskraftsinnsatsen slik den rapporteres til offentlige registre øker for gitt produksjon.
- Den estimerte positive addisjonaliteten er i hovedsak drevet av foretak som investerte svært lite i FoU før SkatteFUNN ble innført.
- Addisjonaliteten synes sterkest i små foretak, foretak i desentrale strøk, foretak hvor de sysselsatte har lavt relativt utdanningsnivå og foretak i næringer som tradisjonelt er lite forskningsintensive. Dette er sterkt relatert til foregående punkt.
- Foretak som gjør lite FoU får relativt sett mer subsidier ut av ordningen enn foretak som gjør mye FoU – selv om man bare sammenligner foretak under beløpsgrensen for fradrag. Dette er konsistent med ordningens popularitet blant svært små foretak. Det er ikke nødvendigvis et problem, men man kan mistenke at enkelte foretak med lite FoU tilpasser seg regelverket på en måte som ikke var tilsiktet.
- Foretak som tidligere ikke investerte i FoU har hatt høyere sannsynlighet for å begynne å investere i FoU etter at SkatteFUNN ble innført.
- Foretak som tidligere investerte i FoU har hatt høyere sannsynlighet for å fortsette med FoU etter at SkatteFUNN ble innført
- SkatteFUNN ser ikke ut til å ha hatt noen sterk effekt på samarbeid med eksterne FoU-institusjoner.
- Analysene gir ikke noe entydig svar på om addisjonaliteten er sterkere på lang sikt enn på kort sikt. Teoretiske betraktninger tilsier at dette bør være tilfelle.
- Selvrapportert addisjonalitet fra søknader og sluttrapporter samt Innovasjon Norges prosjektvurderinger samsvarer kvalitativt med de økonometriske analysene.

I sum tolker vi de empiriske resultatene til å være konsistente med at SkatteFUNN-ordningen har stimulert til økte FoU-investeringer i norske foretak.

Hovedresultatene er stort sett konsistente på tvers av datakilder og modellspesifikasjoner. Imidlertid må vi på nytt minne om at identifikasjonsstrategien ikke er vanntett, og at en kausal tolkning av resultatene hviler på antakelser som neppe holder eksakt. Effektene er estimert med betydelig usikkerhet, og størrelsen på estimatene er sensitive overfor behandlingen av de foretakene som rapporterte minst FoU før SkatteFUNN. De kvantitative resultatene i vår analyse må derfor brukes med varsomhet.

Når det er sagt er det likevel interessant å beregne hva våre estimater betyr med hensyn til hvor mye ekstra FoU som genereres i forhold til hvor mye myndighetene deler ut i støtte. Som et referansepunkt kan det nevnes at et prosjekt som foretas av et foretak under beløpsgrensen, og som ikke ville blitt utført i det hele tatt dersom det ikke fikk støtte, har en addisjonalitet pr. støttekrone på 1/0,20=5 hvis fradragsprosenten er 20 og 1/0,18=5,56 hvis den er 18. Et prosjekt som ville ha blitt gjennomført uansett har addisjonalitet pr støttekrone lik null. Ethvert estimat på addisjonalitet pr støttekrone som er lavere enn 5, innebærer dermed et effektivitetstap i og med at det koster å drive inn skattekroner og noen av disse har gått til prosjekter som uansett ville blitt gjennomført. Dette er det imidlertid vanskelig å unngå. En addisjonalitet større enn 1 regnes vanligvis som akseptabelt i internasjonale evalueringer.

Basert på de ulike estimater fra våre økonometriske undersøkelser finner vi addisjonalitet pr støttekrone mellom 1,3 og 2,9. Det knytter seg som nevnt betydelig usikkerhet til disse estimatene. Siden de ulike estimatene ikke er uavhengige knytter usikkerheten seg til hele intervallet og blir ikke borte ved at man velger et midtpunkt. Skal vi imidlertid gi en beste gjetning på privat FoU-vekst per skattekrone brukt, må denne likevel bli i størrelsesorden 2.

Gitt det positive bildet som avtegner seg i våre mikroøkonometriske analyser, kan den svake veksten i aggregert FoU etter 2002 synes overraskende. Dette kan indikere at vårt anslag på addisjonaliteten ligger noe høyt. Men for det første er det mulig at makrobildet ville sett mer negativt ut uten SkatteFUNN. For det andre er ikke forholdet mellom totale FoU-investeringer og størrelsen på subsidien slik at man kan forvente en veldig sterk makroeffekt.

1. Introduction

Policies to stimulate innovation and economic growth are high on the policy agenda in all OECD-countries. A strong link between investments in research and growth is often taken for granted, and many countries have explicit and ambitious goals regarding the economy's R&D intensity. Setting such goals suggests there is a role for government intervention, and there are many potential market failures in the market for research and development. In theory, these could lead to overinvestment as well as underinvestment, but based on empirical research there is a fairly broad consensus that a free market underinvests in R&D.[1]

There are many policy tools available to improve upon the market outcome. First, governments may produce R&D themselves. Second, intellectual property right laws, ensuring that investors are able to capture the rents from innovations, are very important. Third, there are several important links between competition policies and innovation. Fourth, well regulated capital markets are crucial, and there may also be a role for public money in order to secure funding of new ventures. Finally, the government may subsidize R&D investments made by private firms. OECD countries use large sums on R&D subsidies, and it receives considerable attention in the public debate. However, there is no strong consensus regarding the effectiveness of such policies.

R&D subsidies can be given as R&D tax credits or through direct grants.[2] Tax incentives have become an increasingly popular policy tool over the last decades, and in several countries it is a very important supplement to direct R&D subsidies. In both cases, the aim of the policy from the point of view of the government is to subsidize private R&D projects that would not have been undertaken without a subsidy, and where the social rate of return is above the risk adjusted required rate of return on public investments.

If the government had perfect information, direct subsidies would be the preferred tool, as projects could be given support based on their social rate of return. An R&D tax credit would be less efficient, as firms rank projects according to their *private* returns. Substantial subsidies (financed by tax revenue) will then be paid to projects that would have been undertaken without a subsidy, and where spillovers to other firms or consumers may be small. This implies that under a tax credit there is (*i*) a deadweight loss, since some of the subsidies are pure transfers financed by tax revenues, and (*ii*) a non-optimal mix of projects undertaken because firms decide what projects to do themselves. However, public servants do not have perfect information, and acquiring information on private and particularly social returns is costly. Submitting detailed information on projects is also costly for firms. Depending on how the tax credit scheme is set up, administering subsidies through R&D tax credits may be cheaper for both government and firms. This is one main advantage of using tax credits for R&D. Another main advantage is that R&D tax credits reduce the price on R&D investments. Hence, there is a strong theoretical case for thinking that R&D investments will increase. With direct R&D grants, firms' first priority will be to get subsidies for projects they would undertake in any case. The degree of "additionality" will depend on the quality of public servants and the honesty of firms. Since R&D subsidies are awarded through a discretionary process, it is also more vulnerable to lobbying, which may be a serious drawback. Furthermore, grants may be more vulnerable to politicians' year-to-year budget constraints and short term priorities, than more "rights-based" tax credit schemes. Lack of stability in R&D grants is very unfortunate, as firms' R&D investments are strategic and long term decisions with high adjustment costs.

1.1. The Norwegian R&D tax credit scheme

Introducing an R&D tax credit in Norway was proposed by the Hervik Commission in a green paper for the

[1] See Griliches (2000) for a broad survey and Wieser (2005) for a recent meta-analysis.

[2] See Hall and van Reenen (2000), David, Hall and Toole (2000) and Garcia-Quevedo (2004) for useful surveys. See also Bloom, Griffith and van Reenen (2002) for an authoritative empirical analysis of R&D tax credits.

Ministry of Trade and Industry (NOU 2000:7). The commission was appointed to suggest policy measures aimed at encouraging industry to invest more in R&D. The Norwegian Parliament had earlier in 2000 agreed to make increased R&D investments a national priority, and decided that R&D relative to GDP should at least reach the OECD average by 2005. This illustrates a general point. Generous R&D tax credit schemes are often introduced in countries where R&D investments are low by international standards, and where the sentiment is that "something needs to be done".

The Hervik commission suggested using an R&D tax credit as one of several policy tools to stimulate R&D investments. They emphasized that the R&D tax credit they proposed would be administratively simpler and more robust to informational problems than direct subsidies. It was intended to be the main policy tool towards small and medium sized firms (SMEs). In the commission's opinion, the Norwegian Research Council should focus on R&D of strategic importance, and spend their resources initiating and evaluating large projects. It also emphasized that an R&D tax credit would give more stable conditions for the business community than direct subsidies. The total subsidy would not be subject to annual budget debates, and the detailed regulations would be embedded in the general tax code. Of course, the specifics of the scheme, such as deduction rates and rules on eligibility etc. could change over time, but it was a widely held view that it would be less vulnerable to "overnight" changes than direct subsidies

The tax credit scheme, called SkatteFUNN, was introduced in 2002.[3] SkatteFUNN implies that firms can deduct from tax payable a certain amount of their R&D expenditures. Firms are entitled to the tax credit as long as the R&D-project has been approved by the Research Council of Norway, and the actual expenditures are approved by the tax authorities.

Originally, only SMEs were eligible. SME were defined as firms fulfilling two out of the following three criteria: (i) Fewer than 100 employees (ii) an annual turnover less than 80 million NOK – about 10 million Euros (iii) an annual balance sheet total less than 40 million NOK – about 5 million Euros.

Already in 2003 large enterprises were included as well. Large enterprises may deduct from taxes owed 18 percent of expenses related to an approved R&D project. 20 percent deduction is possible if the following conditions for being a "small enterprise" are fulfilled: (i) Fewer than 250 employees, (ii) an annual turnover not exceeding Euro 40 millions or an annual balance sheet total not exceeding Euro 27 millions and (iii) less than 25 per cent of the company is owned by a large enterprise. This distinction between large and small enterprises follows EU/EEA state aid rules. The maximum allowable sum (i.e. the sum from which the tax deduction is calculated) for R&D projects conducted by the enterprise itself, is NOK 4 millions per year (about Euro 500 000). In cases where enterprises collaborate with an approved R&D institution (universities and institutes), the maximum sum is NOK 8 millions. Stimulating cooperation between academia and commerce is considered an important objective of the scheme.

In order to qualify for the scheme, a project must be limited and focused, and it must be aimed at generating new knowledge, information or experience which is presumed to be of use for the enterprise in developing new or improved products, services or manufacturing/processing methods.

There are no constraints or extra incentives based on sector or region. Enterprises that are not currently liable for taxation are also eligible. If the tax credit exceeds the tax payable by the firm, the difference is paid to the firm like a negative tax or a grant. If the firm is not in a tax position at all, the whole amount of the tax credit is paid to the firm as a grant. In practice this has turned out to be a very important feature, as around three-quarters of the total support given through the scheme is paid out as grants. The payment is made when the tax authorities have completed their tax assessment, and takes place the year after the actual R&D expenses have occurred. The R&D tax credit is thus neutral as between qualifying projects, regions, sectors and the tax position of qualifying firms, but lowers the marginal cost of R&D in small enterprises or low R&D spenders more than in larger ones. For firms that would have spent more on R&D than the maximum amount in the scheme even without the presence of the tax credit, the scheme gives no incentive on the margin to increase R&D investments, although they have a clear incentive to qualify for the scheme and receive the tax deduction.[4]

As from the fiscal year 2007, a maximum hourly rate and a maximum number of hours per year for in-house R&D personnel has been introduced. The ceiling for payroll and indirect expenses has been set at NOK 500 per hour (around 60 Euro). Up to 1850 hours per year may be approved per person associated with the project. This has made the scheme slightly less generous than in previous years.

The Norwegian Parliament has decided to include financial support to unpaid labour in R&D activities in

[3] The following description borrows from OECD (2007, p. 112), Cappelen, Raknerud and Rybalka (2007, Appendix A) and http://web.skattefunn.no/index.php?kat=English

[4] In theory, the presence of liquidity constraints or internal political processes related to the investment budget could also give firms above the maximum amount an incentive to increase their R&D investments.

the tax credit scheme as well, in order to reach high tech entrepreneurs that do not draw wages from their firms. The amendment needs to be approved by the EFTA Surveillance Authority (ESA). A decision was expected in September 2007, but was not yet announced in late November 2007.

The present report concerns the scheme's ability to stimulate extra R&D effort in firms, and is an extension of Hægeland, Kjesbu and Møen (2006). The report uses data up to 2005, and is organized as follows. The next chapter gives an overview of the popularity of the scheme. In addition, we briefly report results from other relevant assessments of the scheme. Chapter 3 gives a thorough discussion of our methodology, related to other strategies used in the literature. The data we use are described in chapter 4. Chapter 5 presents some descriptive analyses, while the results from our econometric analyses are reported in chapter 6. The final chapter concludes.

2 Popularity and some preliminary assessments of the scheme[5]

The Norwegian R&D tax credit has been very popular in the business community. This is perhaps not surprising – tax deductions usually are.

2.1. Number of applications

The number of applications received by the R&D tax credit secretariat has varied over time. In the first year, 2002, there were 3300 applications. When the scheme was made universal in 2003 the number increased to 4700 applications, but thereafter it has gradually fallen. In 2006 there were 2600 applications. About 30 percent of the applications are either rejected or withdrawn. Some of the applications are for projects that last for several years, and the number of "active projects" under the scheme has varied between 5000 and 6000. The total R&D expenses under the scheme have also been fairly stable. The total budget for approved applications has been about 1.1 billion Euro per year. Around two thirds of the R&D expenses are personnel costs.

2.2. Tax deductions

In 2005, the total tax deduction was 135 million Euros. Out of this as much as 100 million Euros was paid out as a grant from the tax authorities to firms that were not in a tax position or would have paid less in taxes than their R&D tax relief. This illustrates that the scheme is particularly popular with small and newly established firms. Roughly 85 percent of all approved projects are undertaken by firms with less than 50 employees. 50-60 percent of the applications are from firms with less than 10 employees. In 2005, these firms performed 45 percent of the total R&D expenses under the scheme. The high R&D activity in this segment is interesting, as the annual R&D statistics from Statistics Norway has not included firms with less than 10 employees. This implies that we lack historical data for an important user group. Obviously, this complicates the evaluation.

For all firms receiving subsidies through the R&D tax credit scheme, the average subsidy is about 1000 Euros per employee. Average tax per employee for the same firms in absence of the subsidy would have been 2300 Euros. Hence, in these terms, the subsidy is rather substantial.

2.3. Applicants

13 percent of all manufacturing firms used the R&D tax credit in 2004, but only 1 percent in construction and most service sectors. Within the service sector, firms using the tax credit are concentrated in two industries, computing (NACE 72) and consulting (NACE 74.1-74.4).

Cappelen et al (2007) report results from an analysis of the probability that a firm will apply for the R&D tax credit. Not surprisingly, they find that the share of highly educated employees is a very important predictor. They also find that young firms are overrepresented, and that firm size is important. Firms with 50-100 or above 100 employees have the highest probability of applying for the tax credit, depending on the industry. Labour productivity is not significant. Interestingly, whether or not the firm is in position to pay a revenue tax seems to affect the decision to apply for SkatteFUNN. The scheme seems particularly attractive to firms that will receive the tax credit as a grant.

2.4. OECD assessment

In a recent survey, OECD (2007, p. 112) describes the Norwegian R&D tax credit scheme as rather generous by international standards. The OECD's "B-index" calculations averaged about 22 percent in 2006. This is well above the OECD average and exceeded only by Canada, the Czech Republic, Portugal, Mexico and Spain. It should be noted, however, that the calculations do not take into account caps in tax deduction schemes. For Norway, therefore, the B-index applies to a firm not constrained by the cap in the SkatteFUNN scheme. Direct government funding of private R&D in 2004 was 0.11 percent of GDP in Norway. This is close to the OECD average, but well above the median.

[5] See Cappelen et al. (2005, 2006 and 2007) for summaries of the research performed by the evaluation team in Statistics Norway. If no explicit reference is given, the figures in this subsection are collected from these reports.

The OECD survey makes some normative comments about the scheme:

> "The broadly neutral construction of the SkatteFUNN is a point in its favour, especially in Norway where there is a long tradition of including regional, social and sectoral goals in industrial policy. Of course, lower taxes on firms have to be compensated by higher taxes elsewhere. It is also possible that firms now claim tax credits against spending that they would not previously have classified as R&D. There is also the question of additionality, to what extent the tax credit generates genuine additional R&D that would not have taken place in its absence. The effectiveness of the SkatteFUNN in stimulating additional private R&D is currently under evaluation. It is relevant, although by no means conclusive, that the tax expenditure over the 2002-2004 period amounted to NOK 3.4 billion, equivalent to more than 400 million, while recorded business R&D spending, which is erratic, did not rise. Preliminary data shows that nominal spending on private R&D recovered somewhat in 2005, but remained slightly below 2003 levels. Finally, there is the possibility that even if the tax credit stimulates genuine additional R&D, the tax expenditures could have been better used in other areas."

2.5. The preliminary report on input additionality

A preliminary report on the input additionality issue was published as part of Statistics Norway's evaluation project, cf. Hægeland, Kjesbu and Møen (2006). Among firms that previously have reported R&D investments, we found that firms receiving an R&D tax credit in 2003 had stronger growth in their R&D investments from 2001 to 2003 than firms not receiving an R&D tax credit in 2003. Obviously, this may be driven by selection into the scheme, and with the scheme being universal from its second year of existence, it is very challenging to construct a valid control group. Hægeland, Kjesbu and Møen (2006) suggested using the 8 million threshold as an identification strategy. They compared applicant firms that previously had invested less than NOK 8 million with applicant firms that previously had invested more than this threshold. Since R&D investments are fairly stable, the latter group should not have a strong incentive to increase their R&D investments because of the R&D tax credit. An increase in their R&D investments would not affect their total subsidy. Only firms that would invest less than the 8 million threshold in absence of the tax credit have their marginal R&D cost affected. Hægeland, Kjesbu and Møen (2006) found that firms that previously invested less than the threshold increase their R&D investments from 2001 to 2003 more than firms that previously had investments above the threshold. They also found that firms that previously did not invest in R&D are more likely to start investing in R&D after the tax credit was introduced, and firms that previously did invest in R&D are more likely to continue.

2.6. Questionnaire surveys about input additionality

The early econometric analysis of Hægeland, Kjesbu and Møen was complemented by a questionnaire survey. Foyn and Kjesbu (2006) reported that 22 percent of firms with projects that were rejected completely abandoned their projects. 24 percent of the firms went through with the project without any changes. The remaining 54 percent were carried through, but at a smaller scale or with a delay. 30 percent of firms with rejected projects agreed that SkatteFUNN has made them more focused on R&D. For firms that had their projects accepted, the question of additionality is more hypothetical. 15 percent say that the project would have been abandoned without the tax subsidy. 13 percent say the project would have been carried through without any changes. The remaining 72 percent say the project would have been carried out at a smaller scale or with a delay. A new survey was conducted in 2007, documented in Foyn (2007). The results are quite similar, but there is a tendency that firms report a somewhat smaller "additionality effect", e.g. 19 percent say that the project would have been abandoned without the tax subsidy. The additionality appears to be larger for small firms

Ljunggren, Brastad, Madsen and Alsos (2006) also conducted a survey on the input additionality in SkatteFUNN. Among applicant firms shortly after they submitted their application, 13 percent report that the project will be abandoned or postponed indefinitely if not supported. 18 percent report that they intend to go through with the project without any changes even if they do not receive support. The remaining 66 percent will be carried through, but at a smaller scale or with a delay. Ljunggren et al. do not find that input additionality vary with firm age, but find a systematic pattern when comparing firms of different size. Additionality is larger for small firms than for large firms.

The results in Foyn and Kjesbu (2006), Foyn (2007) and Ljunggren et al. (2006) are in line with each other and consistent with the preliminary econometric analysis described above. The questionnaire response is also in line with the results from similar questionnaires regarding direct R&D subsidies summarized in Klette and Møen (1998). The reported additionality in SkatteFUNN is, however, far below what Hervik, Bræin, Bremnes and Bergem (2006) find in surveys of firms that have received user-oriented direct R&D subsidies in the years 1997-2005. Hervik et al report that for the years 1997 to 2005, 45 percent of the firms say that their R&D project would have been abandoned without the R&D subsidy. 2 percent say the project

would have been carried through without any changes, and 52 percent say the project would have been carried out at a smaller scale or with a delay. Madsen and Brastad (2006) looking at firms that received support from Innovation Norway in 2002 find that 34 percent of the firms report high input additionality.

3. Methodology

3.1. Identifying the causal effect of SkatteFUNN

In our main analysis, we use a fixed effects regression technique, as we will explain below. Here we discuss the fundamental problem of identifying the causal effect of SkatteFUNN and give a basic intuition for the econometric model that follows. Our approach – and its major weaknesses – can be illustrated by a simple two-group comparison of growth in R&D investments, so-called "difference-in-difference".

In order to identify the causal effect of SkatteFUNN, we must perform a counterfactual analysis. We must compare the actual level of R&D investments with the level of investment that *would* have been realized if the SkatteFUNN scheme *had not* been implemented. Ideally, the counterfactual investment level should be determined by a controlled experiment, randomly dividing the population of firms into two groups, giving one group access to the SkatteFUNN scheme. The effect of the credit could then be measured by the difference in response between the two groups. Obviously, this is not possible, and the challenge in a non-experimental setting is to deduct from historical data what the situation would have been if the tax incentive scheme had not been launched. In general, one does not have a guarantee that historical data can reveal what would have happened under a different policy regime.

Unfortunately – from an evaluation perspective – all Norwegian firms have access to SkatteFUNN from 2003 onwards. The first idea that springs to mind may be to compare those who choos to apply for the R&D tax credit with those who choose not to use the credit, but this will not mimic the golden standard of having two randomly selected groups. Those who *choose* to use the tax credit presumably see some profitable R&D investment opportunities, while those who *choose not* to use the scheme presumably do not see any profitable R&D investments opportunities. In this situation we cannot use the investment level of the firms that do not use the R&D tax credit to infer how much the firms that use the R&D tax credit would have invested in absence of the scheme.

What we propose to exploit is a discontinuity built into the scheme. The R&D tax credit is limited to investments up to 4 million NOK in intramural R&D or 8 million NOK in total R&D. Firms that would invest *above* this cap in absence of the R&D tax credit scheme will receive a subsidy, but increasing their R&D investments will not increase the subsidy as they are already above the maximum possible subsidy. Hence, they do not receive any subsidies on their marginal investments.[6] Firms that would invest *less* than the cap in absence of the scheme will, on the other hand, have an incentive to increase their R&D investments as this will increase their subsidy. They receive an 18-20 percent subsidy on each extra krone they invest in R&D up to the cap. One may conceive that whether a firm's investment level in absence of the R&D tax credit scheme will be above or below the cap is somewhat random. Our main identification strategy is therefore to compare the two groups and *assume* that the difference in R&D growth between the groups is because one of the groups receives a tax credit for their marginal R&D investment. Stated differently, we assume that firms' growth in R&D investments is not systematically related to whether they would invest above or below the cap in absence of SkatteFUNN. This is not an innocuous assumption. It is not obvious that firms with small and large R&D investments have the same expected growth rate in absence of the scheme. Moreover, difference in measured growth rates will be influenced by "regression-to-the-mean" to the extent that firms' R&D investments tend to deviate temporarily from a typical level. Firms that had an "unusually" high R&D investment level in the pre SkatteFUNN period will tend to be classified above the cap and at the same time they will be expected to reduce their R&D investment level. Firms that had an "unusually"

[6] If firms are liquidity constrained, there could be a positive effect also on firms above the cap. Moreover, firms that would do more than 4 million in intramural R&D but less than 8 million in total R&D may have an incentive to substitute intramural R&D for extramural R&D. We abstract from this. With respect to liquidity constraint, we have experimented with including cash flow as a control variable in our main regressions, but somewhat surprisingly, we did not find any evidence suggesting that R&D investments were sensitive to the firms' cash flow.

low R&D investment level in the pre SkatteFUNN period will tend to be classified below the cap and at the same time they will be expected to increase their R&D investment level.

Before we can compare R&D growth between firms that would invest above or below the cap in absence of the scheme, we need to determine which firm belongs to which group. This is a challenge. After all, how much the firms would invest in absence of the scheme is the question we try to answer. A simple approach is to divide the sample into two groups based on their average level of R&D-investments before the introduction of SkatteFUNN. Firm- level R&D investments are known to be fairly stable over time, cf. Klette and Johansen (1998), so the majority of firms that invested less than the cap before the SkatteFUNN scheme was introduced, would likely continue to invest less than the cap in absence of the scheme, and vice versa. Predicting future R&D based on pre SkatteFUNN average R&D will be less vulnerable to a regression-to-the-mean-bias than an approach using only the most recent R&D observation. However, the closer a firm's historical R&D investments are to the cap, the more uncertain the classification. Mixing up the two groups will cause the measured difference to be smaller than the true difference. To the extent that average R&D put too little emphasis on the most recent R&D observation, this will add to the contamination of the treatment and control groups.

When using a "discontinuity approach" to evaluate effects, one usually tries to secure comparability of the two groups by narrowing the sample down to firms right above and right below the point of discontinuity or cap in the scheme. In our case this implies a very unpleasant trade-off. Not only does it cause a costly loss of observations, but the more we narrow down the sample in order to improve the comparability of the two groups, the more likely it is that firms are misclassified. The choice we make in our main analysis is to restrict the sample to firms that are observed with positive R&D investments in at least one year prior to the introduction of SkatteFUNN and that never are observed with investments above 40 million NOK in a single year. Hence all firms in the sample are R&D performers, and the largest R&D performers are excluded. This way we hope to enhance comparability while retaining a fairly large sample with the majority of firms being clearly above or below the cap.

Excluding firms that have not previously reported R&D is unfortunate from an evaluation point of view. The scheme aims to incur such firms to start investing in R&D. However, we choose to investigate the probability of starting to invest in R&D in a separate analysis since the decision to invest in R&D *for the first time* may be rather different from the decision to *change the level* of R&D investments.

Table 3.1. Growth in R&D for firms with and without a tax subsidy on the margin

Growth in real intramural R&D from 2001 to 2003	Average pre 2002 intramural R&D investments		Difference[1]
	Below 4 mill.	Above 4 mill.	
10th percentile	-2	-1.59	-0.41
Median	0	-0.10	0.10
90th percentile	2	0.76	1.24
Average	-0.08	-0.22	0.14
Standard error	1.19	0.89	
Average pre 2002 intramural R&D	948 000	9 489 000	
N	687	230	

[1] The difference between the two distributions is significant at the 1% level.

In table 3.1. we report descriptive statistics on growth in real intramural R&D from 2001 to 2003 for firms in the sample that were present in both surveys and received a tax credit in 2003. In line with the identification strategy suggested, we split the sample in two groups and compare firms with average R&D investments prior to SkatteFUNN above and below the 4 million cap. Only firms observed with positive R&D investments in some year prior to SkatteFUNN are included. R&D growth is calculated as

$$(R\&D_{2003} - R\&D_{2001})/(0{,}5 * R\&D_{2001} + 0{,}5 * R\&D_{2003})$$

in order to reduce the influence of outliers and to allow including firms with zero R&D in 2003. Measuring growth by log differences gives very similar results to the ones reported below. The significance tests and median difference between the groups is almost exactly the same while the standard deviations and average difference are larger.

We see that the group that used to invested less than 4 million NOK in R&D prior to SkatteFUNN on average had 14 percentage points higher growth rate from 2001 to 2003 as compared to the group that invested more than 4 million NOK in R&D in 2001. A two sample mean comparison t-test with unequal variance gives a p-value close to zero. The non-parametric Mann-Whitney two sample rank-sum test also gives a p-value close to zero. Hence the difference between the two groups is statistically very significant. The results in table 3.1 therefore suggest that the Norwegian R&D tax credit scheme do stimulate additional R&D. Before jumping to conclusions, however, one should note that the number of observations available for the analysis is low compared to the number of firms using the scheme and the average level of intramural R&D prior to 2002 differs markedly between the two groups. This is a reminder of the prior caveats, and that it may be difficult to reach a strong conclusion given the available data and the design of the scheme. In particular, we cannot distinguish between the effect of SkatteFUNN and other possible changes in the macro environment that affect small and large R&D performers differently. Furthermore, leaving out firms that reported no R&D in 2001 makes the difference

between the two groups smaller and insignificant. Hence, the positive effect seems to be driven by firms that did very little R&D prior to SkatteFUNN.

In our main analysis the, two-group comparison is embedded in a regression analysis. This has several advantages. First, we can include control variables. This will make the two groups more comparable, and also improve the precision of statistical tests by reducing the unexplained variance. Second, we can utilize all observations of the firms, not only one year prior to SkatteFUNN and one year after. This will give us a more precise estimate of the change caused by SkatteFUNN for the firms used in the above analysis, and also make it possible to include firms that were missing from one or both of the surveys in 2001 and 2003. Finally, within a regression framework we can answer more specific questions such as whether long term effects differ from short term effects, and whether certain firm characteristics are associated with particularly high or low additionality. However, the fundamental identification problem described above still remains.

Before developing the regression framework in detail, we will review different approaches used to analyze additionality in R&D tax credit schemes in the previous literature.

3.2. Identification strategies in the previous literature

We are to answer an apparently simple question: Has SkatteFUNN led to increased R&D investments? We "know" from our data, what the situation was *before* the scheme was introduced. We also know what the situation is *now* in the *presence* of the scheme. However, finding the causal effect implies answering the counterfactual question: What would the situation have been now in the *absence* of the scheme? The methods briefly described below are in principle suited to do so, given that certain assumptions are not violated. The most important assumption is that firms' access to the scheme, or variations in generosity of the scheme over time and between firms are not related to factors which cannot be controlled for in the analysis, that are themselves related to the level of R&D investments. I.e., there must be some randomness in treatment. However, such variation may be rare, or in some cases even absent.

Not all "other factors" related to R&D investments cause problems. Many of them are directly observable and can be controlled for in the analysis. Estimating econometric equations in differenced form or using panel data techniques may also control for unobserved differences between firms that are constant over time. The main problem arises when firms' access to or use of the scheme are correlated with unobserved factors which vary over time. This point makes it particularly problematic to look at firms who apply for support through the scheme, using those firms that do not apply as a comparison group. Firms that get a good research idea are more likely to apply for support through the scheme, but they would also be more likely to carry out the project in the absence of the support. Hence, firms "within" the scheme and outside the scheme are likely to differ with respect to "research ideas", an unobservable and time-varying variable.

Ideally, the question of whether a specific measure works or not should be answered by carrying out a controlled experiment, randomly dividing the population of firms into two groups, giving one group access to the scheme. This would provide us with the exogenous variation we need, and we can compare a treatment group with a control group using the above framework. This ideal situation is almost never feasible, cf. Jaffe (2002).

Schemes and measures are often general in nature. This creates great challenges for evaluators. The more general the scheme, i.e. the more equally similar firms are treated in the scheme, the more complicated is the evaluation. The reason is that a higher degree of "generality" or "equal treatment" brings us further away from the ideal evaluation setting. When all comparable firms either have access to the scheme or not, it is impossible to construct a control group telling us anything about the counterfactual situation.

The challenge in a non-experimental setting, without a formal control group, is to deduct from historical data, what the situation would have been if scheme had not been launched. In the absence of a controlled experiment, one needs to look for so-called quasi-experiments built into the scheme. A quasi-experiment is e.g. variations in the scheme that may be regarded as "random" at least on the margin. In our setting, randomness implies that the variations are not systematically related to (unobserved) variables that affect firm's R&D decisions. A potential quasi-experiment would be variations in the generosity of the scheme with respect to firm characteristics that are relatively fixed in the short term, e.g. number of employees. Assuming that firms around the border of the size restriction are comparable, and that it is in a sense random whether they were eligible for support through the scheme or not, this discontinuity creates a quasi-experiment, and one may study the effect by comparing firms just above and just below the threshold.

The most authoritative survey on the effects of tax incentives on R&D investments is Hall and van Reenen (2000). In this section, we focus on the methods that are described in their article, and do not discuss their empirical results in detail. The main conclusion in this respect is that one dollar in R&D support given through

tax incentives seems to give one dollar in increased R&D investments, i.e. that companies use the support given – no more and no less – to increase their R&D. They emphasize that there is substantial uncertainty with respect to this estimate, and they have critical remarks to the methodological approach taken by many of the studies they review.

Hall and van Reenen (2000) group the literature into five different frameworks and the exposition below borrows heavily from their work.

1. Event studies
2. Case studies
3. R&D demand equation with shift parameter for existence of a tax credit scheme
4. Demand equation with user cost of R&D
5. Structural estimation of R&D investments

Below, we explain each of these, and discuss strengths and weaknesses in relation to evaluating the Norwegian scheme.

Event studies

Event studies will typically consider the launching of the fiscal measure as a sudden and surprising event for firms. Under this assumption, one can measure effects of the scheme by doing before-after comparisons. The most common outcome variable used in event studies is the market value of firms, thereby measuring how the stock market estimates the value of the scheme in terms of returns that accrue to firms. This is probably not an adequate evaluation method for the Norwegian SkatteFUNN scheme. First, the scheme was not launched as a sudden event, but was the result of a long debate, and announced in advance. This may have created expectations that have affected the valuation of firms. Second, the method is relevant only for publicly traded firms, where information on market value is readily available. Third, the change in the private valuation of firms will tell us little about the social returns to the scheme, and hardly anything about to which extent the scheme stimulates R&D investments. One possibility is to do event studies with R&D investments as the outcome variable. In such studies, R&D investments after the scheme is launched are compared to the investment level that was planned before the fiscal measure was announced. Several countries gather such information in their R&D surveys. In Norway, firms are asked about their planned level of R&D investments one and two years ahead. In principle, therefore, one can compare what companies in 2001 planned for 2003 with their actual R&D investments in 2003. But it is problematic to assume that SkatteFUNN came as a surprise after the R&D survey for 2001 was carried out in the spring of 2002.

Though the methodology used in event studies is intuitively appealing, it has its weaknesses. The most obvious weakness is that it is difficult to control for the effects on the outcome variable of other events or trends that appear simultaneously with the event one focuses on. In our setting, there may be other reasons for deviations between planned and actual R&D than the introduction of the fiscal measure. Event studies are most suitable to study sudden events where effects materialize quickly. Neither of these criteria is likely to be fulfilled in the case of fiscal measures for R&D, and certainly not in the case of SkatteFUNN.

Case studies/questionnaire surveys

Hall and van Reenen (2000) consider case studies as "retrospective event studies". The method is straightforward. Involved actors are asked whether the launching of a fiscal measure had any effect on variables and factors that are of interest to the evaluator, e.g. R&D investments. The major advantage of this approach is that respondents implicitly control for other external conditions when they answer the questions. Another advantage is that case studies and surveys may capture more qualitative effects, which may not be easily identifiable through other data sources.

Case studies and surveys are very useful, and should probably constitute an important part of any thorough evaluation. However, they do have shortcomings, and should be supplemented by other methods, as is also the case in the Norwegian evaluation of SkatteFUNN. As Hall and van Reenen point out, respondents may have the incentive to answer strategically. If they feel that their response may have importance for the continuation of the scheme, they may adjust their answer accordingly. E.g., if they think that a finding of a large input additionality increases the probability that the scheme is continued; they may exaggerate the effect on R&D investments. Even if the respondents do not answer strategically, it is far from obvious that they are able to isolate the effect of the fiscal measure from other factors. This may not be a problem if the error is not systematically related to the real effects of the fiscal measure. However, this may not be the case. For example, there might a tendency that managers with positive results overestimate the effects of their own effort, while those with negative results exaggerate the impact of external factors.

R&D demand equation with shift parameter for existence of a tax credit scheme

This approach is used in a large number of studies. The point of departure is a regression equation that predicts R&D investments at the firm level, including a variable that indicates whether the firm had access to the tax credit, in addition to other variables that affect R&D investments.

$$(3.1)\quad \ln(R\,\&\,D) = \alpha + \beta C_{it} + \gamma' x_{it} + u_{it}$$

This equation expresses the logarithm of the R&D investments of firm *i* in year *t* as a function of the presence of a fiscal measure (C_{it} equals one if firm *i* had access to the scheme in year t and zero otherwise) and other variables, which are contained in the vector x_{it}. Such variables may be previous R&D investments, previous output, expected future output, cash flow, product prices etc.

The β-parameter measures the expected growth of R&D-investments following a firm getting access to the scheme. The basic framework assumes that this effect is identical across firms. This assumption is hardly innocuous, but it is not discussed by Hall and van Reenen. Such models should be estimated on micro data, to utilize cross-section variations in access to the scheme across firms. Using macro data only, it is impossible to distinguish the effects of the scheme from unobserved macroeconomic shocks.

Demand equation with user cost of R&D

This approach has very much in common with the one described above. The major difference is that instead of just including a variable indicating existence of or access to a fiscal measure for R&D, one calculates the so-called "user cost" of R&D investments, i.e. a variable that reflects the price of R&D investments for the firm, on the margin, taking into account R&D fiscal measures, other tax rules, interest rates and depreciation. The introduction of say a tax deduction scheme for R&D will reduce the user cost of R&D.

$$(3.2)\quad \ln(R\,\&\,D) = \alpha + \beta\rho_{it} + \gamma' x_{it} + u_{it}$$

The key advantage of the user cost approach compared to the shift paramter approach is that one may utilize variations in the generosity of the scheme across firms, and also changes over time. Such variation may be very useful in identifying the effect of the scheme. In addition, variations in other components of the user cost (tax rules, interest rates, depreciation rates) may in theory help in identifying the effects of the fiscal measure.

Within this framework, one may calculate the price elasticity of R&D, that is, how large the percentage change of R&D investments that follows from a one percentage change in the user cost.

The user cost is calculated by calculating what it costs for a profit- maximizing firm to invest "an additional dollar" in R&D at time *t,* and then "sell" this project in the next period. The tax system affects this cost in two respects. First, the return to the investment is taxed at a rate τ_t. Second, the investment cost, is reduced by the tax subsidy and the allowed tax depreciation. Let A^d_{it} denote the present value of this depreciation, and A^c_{it} be the present value of the tax subsidy. The user cost may then be expressed by

$$\rho_{it} = \frac{1-\left(A^d_{jt} + A^c_{jt}\right)}{1-\tau_t}\left(r_t + \delta_j\right).$$

Until quite recently, Norwegian firms have been allowed to write off R&D investments immediately. This implies that $A^d_{it} = \tau_t$. Under the SkatteFUNN scheme, Norwegian firms get tax deductions for intramural R&D investments up to 4 million NOK, (8 million when including extramural R&D bought from approved research institutions.) Looking at intramural R&D we then have $A^c_{it} = \tau^c_t$ if $R\&D_{it} < 4$ millions and $A^c_{it} = 0$ if $R\&D_{it} \geq 4$ millions. r_t is the interest rate, and δ_i is the private depreciation rate for R&D investments.

It is typically ln($_{it}$) that enters the demand equation. Then the user cost is separable in a tax component and a component that varies with the interest rate and the depreciation rate. With Norwegian tax rules, the tax component of the user cost becomes

$$\ln\left(\rho^{\tau}_{it}\right) = \ln\left(\frac{1-\tau_t-\tau^c_t D}{1-\tau_t}\right)$$ where D= 0 if $R\&D_{it} \geq$ 4 millions or t<2002

and

D=1 if $R\&D_{it}$<4 millions and t ≥ 2003 or $R\&D_{it}$<4 millions and t=2002 and the firm is an SME.

We then have

$$\ln\left(\rho_{it}\right) = 0 \qquad \text{if D=0}$$

$$\ln\left(\rho^{\tau}_{it}\right) = \ln\left(\frac{1-\tau_t-\tau^c_t}{1-\tau_t}\right) = \ln\left(\frac{1-0{,}28-0{,}20}{1-0{,}28}\right) \approx -0{,}33$$

if D=1

Here we have abstracted from the small variation in τ^c_t between SMEs (20 percent) and large firms (18 percent) after 2002. It is of course easy to incorporate this into our framework, but it contributes so little to variation in the user cost that it will hardly have any practical consequences for the identification. In principle, an advantage of employing a user cost approach is that the interest- and depreciation component of the user cost may be calculated, and may vary, also in the period prior to the introduction in the scheme. Such variation will help identification. In practice, however, this component will be imprecisely measured and only vary across time. Even in the time dimension, the variation will usually be modest. Hall and van Reenen state that estimates based on this variation may be of limited reliability, and strongly dependent on which other control variables are included in the regression model.

Looking at the expressions for the tax component of the user cost deducted above using the Norwegian SkatteFUNN scheme, two things are worth noting. First, the user cost takes on only two values. In other words, there is little difference between using a dummy variable indicating whether a firm has access to SkatteFUNN and calculating a user cost. Our point of departure will therefore be the more simple approach by estimating a shift parameter. Second, the cross-section variation in the user cost is endogenous, since the price of R&D depends directly on the level of R&D investments in year *t* via the indicator variable *D*. At the same time, the level of R&D investments is the dependent variable in the analysis, i.e. what we are attempting to measure the effect on. A consistent estimate of β then depends on the existence of valid instrumental variables, i.e. variables that help us predict whether the firm will be above or below 4 millions in R&D investments, but have no additional effects on R&D investments. It is obvious that finding such a variable is very difficult, and this endogeneity problem therefore poses a fundamental challenge in the evaluation.

The theoretical foundation for the demand equations sketched above is poorly developed, and some researchers have called for a more structural approach. As Hall and van Reenen state, this is easier said than done. Empirical testing of structural models of investment in physical capital has yielded disappointing results. Modelling investments in R&D is even more demanding, because of the high degree of idiosyncratic risk and substantial capital market imperfections. In empirical work, it is also far more difficult to calculate the stock of R&D capital than to calculate the stock of physical capital. However, Hall and van Reenen formulate a simple structural model that may motivate the demand equations of the user cost type described above. This model yields the following equation to be estimated:

$$(3.3)\ \ln(R\,\&\,D) = \alpha + \beta\rho_{it} + \gamma \ln(output)_{it} + \eta_i + u_{it}$$

One of the assumptions of behind this equation is that the R&D investments in each firm have an approximately constant growth rate. We see that the x vector of control variables now only contains the log of output (sales). Furthermore, a firm-specific error component is included.

One problem that this model does not take into account is that there may be substantial adjustment costs for a firm associated with changing its R&D investments. In empirical specifications, this is often incorporated by including R&D in the previous period as an explanatory variable. Typically the estimated coefficient on this variable is large, reflecting the stability in firms' R&D investment. Temporary shocks will only affect the level of investment to a limited extent, and it may take relatively long time before the full effect of even permanent shocks is observed. This problem is related to the fact that there are large fixed costs associated with having an ongoing R&D activity, e.g. having an own R&D department within a firm, and that R&D investments to a large extent are sunk costs. According to Hall and van Reenen, this casts doubts on how well the linear specifications above approximate the real world. As a minimum, they suggest that the decision to become an R&D-investing firm is modelled separately from the decision on *how much* to invest in R&D, conditional on having built up R&D competence.

3.3. How our identification strategy relates to the previous literature

We will use the semi-structural equation (3.3) above as point of departure for our econometric model. As explained in section 3.2.4, however, the user price basically takes on two values under the Norwegian scheme. Therefore, we will exchange the user price for a dummy variable being one if a firm is predicted to be eligible for a tax credit on their marginal R&D investment.

4. Data

General firm information is collected from numerous sources available in Statistics Norway and covers the entire population of Norwegian firms: Structural statistics, accounts statistic, the tax register, the register of employers and employees and the national education database.

Information related to R&D investments and R&D subsidies are *not* available for the entire population of firms. Prior to the introduction of SkatteFUNN, information on firm level R&D investments are available from the R&D surveys collected every second year by Statistics Norway up to 2001 and annually thereafter. All firms with more than 50 employees are included, and a stratified sample of firms with 10-50 employees. In 2003 a survey was also conducted on firms with less than 10 employees. We use surveys from 1993 onwards.

After the introduction of SkatteFUNN, R&D information has also been collected by the Research Council of Norway among the SkatteFUNN applicants. Some of this information covers the years before the firms apply for support and before the scheme was introduced.

There are 17 290 firm year observations in the R&D surveys in the years 1993-2001, i.e. prior to SkatteFUNN. 26 % of these report positive R&D (intramural, extramural or both). After the introduction of SkatteFUNN, in the years 2002-2005, there are 16 464 firm year observations. Out of these 33 % report positive R&D and 20 %, 3249 firm year observations, have applied for an R&D tax credit. The 3249 firm year observations that applied for a tax credit within the R&D surveys constitute only 24 % of the 13 884 firm year R&D tax credit applications in the years 2002 to 2005. Of these 13 884 applications, 11 144, i.e. 80 %, received a tax credit.

Table 4.1 split firm-year observations that either have received an R&D tax credit or have been included in an R&D survey on employment groups. As one can easily see, firms in the R&D surveys are not a representative sample of the SkatteFUNN firms. The SkattteFUNN data base is dominated by very small firms while the R&D surveys are dominated by medium sized firms.

Table 4.1. Firm year observations 2002-2005 by data base and number of employees

Included in the SkatteFUNN database	Yes	Yes	Yes		No	No
Included in the R&D survey		No	Yes	Yes	Yes	Yes
Positive R&D					Yes	No
No or missing employees	2158	2158	0	1	0	1
1-9 employees	5786	5700	86	537	62	389
10-19 employees	2065	1371	694	5204	464	4046
20-49 employees	2030	1135	895	3927	496	2536
50-99 employees	952	194	758	2885	548	1579
100-199 employees	415	31	384	2025	462	1179
200 or more employees	478	46	432	1885	556	887
Total	13884	10635	3249	16464	2598	10617

There are 2598 firm -year observations from 2002 onwards that report positive R&D without having applied for a tax credit[7]. This is 47 % of the firms in the R&D surveys with positive R&D. The median R&D for firms with positive R&D that do not apply is only half of the median R&D for firms with positive R&D that do apply. However, average R&D for the two groups is about the same, as some of the firms that do not apply are very large R&D performers. That the group of non-applicants contains both very small and very large R&D performers seems natural.

There are 254 firm-year observations with a positive R&D tax credit that report no R&D in the R&D surveys. This suggests that zeros in the R&D surveys are not entirely reliable. Some firms may claim to do no R&D as a way to minimize time spent on the survey, and there may be errors in the processing of the data.

Out of the 11 144 firm year observations with a positive R&D tax credit, 70 % had all of the tax credit associated with intramural R&D, and 1 % had all of the tax credit associated with extramural R&D. Hence, 29 % had a tax credit associated with both intramural and extramural R&D. 18 % reached the tax credit cap for intramural R&D and 0.5 % reached the cap for total R&D. [8]

See Hægeland et al (2006), Kjesbu (2006) and Cappelen et al (2007, Appendix B) for more detailed information about the various sources and variables. Cappelen et al (2007) is written in English, the others in Norwegian.

[7] Note that large firms in 2002 were not eligible, but adjusting for this does not change the numbers below much.

[8] There are 877 firm-year observations in the R&D surveys that have reached the cap for intramural R&D. 261 of these actually report less than 4 million in intramural R&D, and 194 report less than 3 million. This illustrate that for some firms, the "formula" for calculating R&D costs in the SkatteFUNN application is rather generous. There are no incidences in the R&D surveys of firms reaching the cap for total R&D and reporting less than 8 million in total R&D. Note also that there are 300 firm-year observations in the R&D surveys of firms that get a tax credit and report more than 4 million in intramural R&D without reaching the tax credit cap. 207 of these report more than 5 million in intramural R&D.

5. Descriptive analyses

5.1. Do R&D expenditures in the R&D surveys match R&D expenditures reported in SkatteFUNN-data?

In our econometric analyses, we utilize data from both the R&D surveys and from the SkatteFUNN database. It is interesting to know whether firms report similar figures in these two data sources. Since there is a cap on project size in the tax credit scheme, there is no reason for firms with total R&D above the cap to apply for a tax credit for all their projects. We therefore restrict attention to firms that report less than 4 million intramural R&D in the R&D surveys. Since some applications to SkatteFUNN are rejected or withdrawn, and some approved projects are never started, we also restrict the sample to firms that received a tax credit.

Table 5.1 shows that figures in the R&D survey and the SkatteFUNN application are of similar magnitude, but budgeted costs in the SkatteFUNN applications tend to be larger. This could indicate that costs are exaggerated, or at least that the cost formula used for the tax credit calculations is somewhat generous compared to what counts as R&D in the R&D statistics. Having a scheme that allows R&D projects to include more overhead costs than what one chooses to classified as R&D in the R&D statistics is, however, not a problem as long as the formula used to calculate the overhead is not out of proportion generous and easy to manipulate. Evaluated at the median, the application budget in SkatteFUNN is 21 % larger than R&D reported in the R&D survey. Evaluated at the mean, the application budget is 34 % larger than R&D reported in the R&D surveys. Some of this difference may be due to the project being scaled down by the firm after the application is submitted. Evaluated at the mean, the actual R&D costs accepted for the tax credit is 6 % lower than the budget, but this is nonetheless 25 % more than what is reported in the R&D surveys. Evaluated at the median, the actual R&D costs accepted for the tax credit is 9 % lower than the budget, and 9 % more than what is reported in the R&D surveys.

The comparability of numbers in the R&D survey and SkatteFUNN data base is of particular importance around the cap as the difference between firms above and below the cap is central to out identification strategy. When redoing the analysis behind table 5.1 for firms with intramural R&D between 3 and 4 million we find that the numbers are very close to each other for this group which consists of 248 observations. Median intramural R&D is 3561. Median intramural R&D in the SkatteFUNN application is 3580 and median intramural R&D accepted for the tax credit is 3545. Mean values are 3547, 3460 and 3522, respectively. Based on this it seems acceptable to distinguish firms above and below the cap according to R&D as reported in the R&D surveys.

Table 5.1. Comparing R&D costs in the SkatteFUNN application and the R&D surveys for firms with less than 4 million intramural R&D

	R&D survey		SkatteFUNN application		N
	Median	Mean	Median	Mean	
Total Intramural R&D	1654	1759	2000	2358	1578
Personnel costs	1049	1270	1397	1696	1578
Scientific equipment[1]	0	139	0	132	1578
Other operational costs	198	344	251	530	1578
Extamural R&D[2]	0	382	0	283	1578

[1] The 75th percentile is 200 in the R&D surveys and 120 in the tax credit applications.

[2] The 90th percentile is 500 in the R&D surveys and 651 in the tax credit applications.

Numbers are in million 2003 NOK. The sample consists of firm year observations with less than 4 million intramural R&D in the R&D surveys and that received an R&D tax credit.

Figure 5.1. Estimated distributions of intramural R&D

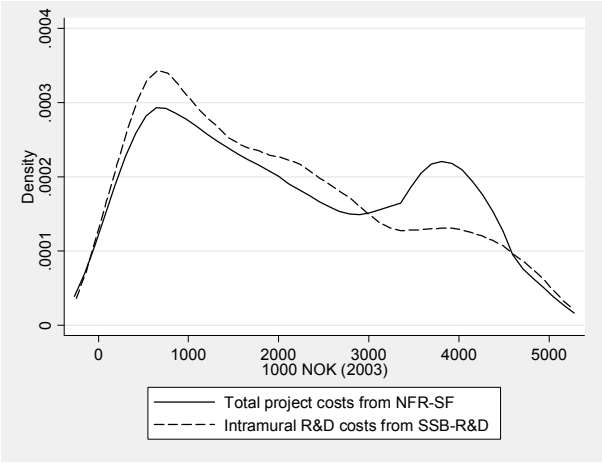


Figure 5.2. Estimated distributions of R&D personnel costs

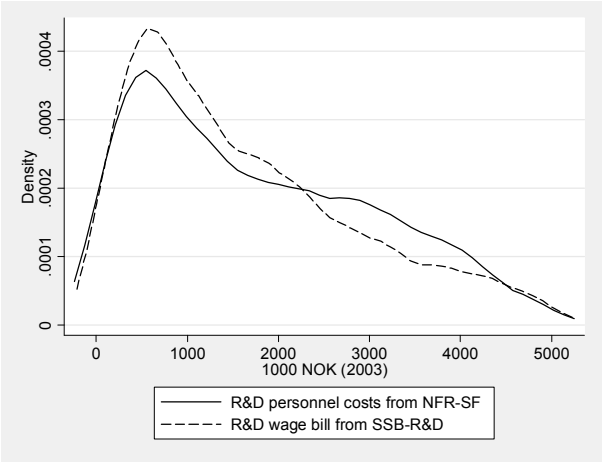


Figure 5.1 graphs the distribution of total intramural R&D in the R&D surveys and in the tax credit database restricting the sample to firms that report positive values below 5 million NOK in both sources. Again, we see that the two sources correspond, but numbers in the R&D tax credit database are slightly larger with a hump around the 4 million cap.

Personnel costs, including indirect costs, in the SkatteFUNN applications are of particular interest as they are estimated based on a formula rather than being based on true wage costs as in the R&D surveys. Personnel- and indirect costs are based on hours worked on the project by the firms' employees multiplied with a hourly cost set to 0,0016 of the employees annual contracted wage. With 1950 hours in a standard man year, this implies that personnel- and indirect costs for one man-year will be 3,2 times annual wage. This is to cover wage, social insurance, housing rent, office support etc. One would expect this to be larger than the R&D wage bill reported in the R&D survey even though this also includes social insurance and may include some support personnel. Figure 5.2 give estimated distributions of the same type as Figure 5.1.

Table 5.2. The ratio of personnel costs in the SkatteFUNN application to personnel costs in the R&D surveys for firms with less than 4 million intramural R&D

Intramural R&D in mill 2003 NOK	Median	Mean	St. dev	N
All firms, 0-4	1.19	1.74	2.03	1577
0-0,5	1.65	3.00	4.13	221
0,5-1	1.29	1.85	1.51	298
1-2	1.25	1.67	1.52	433
2-3	1.13	1.36	0.99	377
3-4	1.00	1.20	0.99	248

Numbers are in million 2003 NOK. The sample consists of firm year observations with less than 4 million intramural R&D in the R&D surveys and that received an R&D tax credit.

Similar to table 5.1. we see that the distribution of personnel costs in the application is somewhat shifted to the right compared with the distribution of personnel costs in the R&D surveys. This again is consistent with the formula used in the application being somewhat generous. In order to study this in more detail, we construct for each firm the ratio of tax credit application personnel costs to R&D survey personnel costs. Table 5.2 give the ratio of personnel costs in the SkatteFUNN application and the R&D surveys by total intramural R&D reported in the R&D surveys.

For the full sample we see that the median of the ratios is 1.19. There is, however, substantial variation, and some large outliers with a very high ratio. The max value is 37.5 and the min value is 0.[9] The mean value is 1.74 and the standard deviation is 2.03.

Looking at the ratio by the size of total intramural R&D as reported in the R&D surveys, we see that both the ratio itself and the variance of the ratio fall systematically by the size of the R&D budget. For firms close to the cap, the median ratio is exactly one. The mean value is 1.2 and the standard deviation is 0.99. A standard deviation close to one shows that even in this group, there is large heterogeneity.

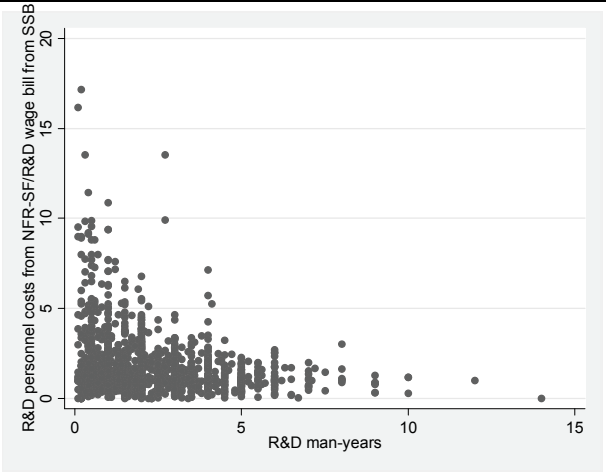
Figure 5.3 plots the ratio of personnel costs in the SkatteFUNN application and the R&D surveys against the firms' reported R&D man-years in the R&D survey.

This illustrates clearly how extreme indirect costs are associated with small R&D performers. Plotting the same ratios against the firms' number of employees in figure 5.4 reveals that small R&D performers "exploiting" the formula are not necessarily small firms.

Given the generous overhead implicit in the calculation of indirect costs, it is also interesting to note that "other operational costs" are quite a bit larger in the SkatteFUNN application than in the R&D surveys.

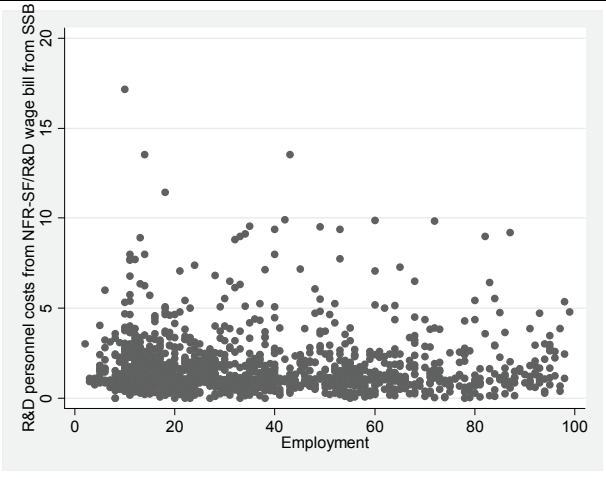
[9] The fact that many firms have a ratio smaller than one may suggest that even among firms that do less than 4 million intramural R&D, there are projects that are not submitted to SkatteFUNN. This is puzzling, and it may also conceal overreporting on projects submitted, as these "low ratio firms" reduce the median and average numbers in table 5.1 and 5.2.

Figure 5.3. The ratio of personnel costs in the SkatteFUNN application and the R&D surveys by R&D man-years[1]



[1] One outlier observation with ratio equal to 37.5 is excluded from the plot.

Figure 5.4. The ratio of personnel costs in the SkatteFUNN application and the R&D surveys by total employment[1]



1 One outlying observation with ratio equal to 37.5 is excluded from the plot.

5.2. R&D tax credits reported in the R&D surveys

Starting with the R&D survey for 2002, firms have been asked to report the R&D tax credit alongside other R&D subsidies used to finance their R&D investments. The surveys are conducted in the year after the investment year, and firms should have sufficient information to answer the question. The figures reported in the R&D surveys seem quite unreliable, however. Only half of the firms receiving an R&D tax credit report this in the R&D surveys. Among those who report such support, only about 30% report numbers that deviate less than 10 000 NOK, from the true numbers, and there is a slight tendency to underreport. Some firms clearly report numbers for the wrong year.

5.3. How large is the subsidy?

The average SkatteFUNN firm applies for a total R&D budget across their projects in the order of 2.4 million NOK. The median firm applies for 1.6 million NOK. The smallest application is only 1000 NOK and the first percentile is 65 000 NOK. With 13 353 observations this implies that there are more than 130 applications smaller than 65 000. An R&D project of 65 000 should expect an R&D tax credit of about 13 000 NOK. This figure suggests that the application costs for the firms must be small – at least for small projects. This is in line with estimates in Foyn (2007) based on what firms report in a questionnaire survey. They find that the average firm spend 30 hours on the application and 10 hours on the end report. Assuming an hourly costs of 365, following SSØ, this suggests an average application cost is in the order of NOK 15 000. Auditing costs seems to add another 5000 NOK for the average project. Another important cost component is the time spent on documenting for the auditor and tax authorities time and costs that has been allocated to the project. Presumably time spent on the application, reports and auditing varies with the size of the project.

Turning to the actual R&D tax credits granted, the average firm with their application accepted, receives 393 000 NOK. The median firm receives 313 000 NOK. The smallest registered tax credit is 370 NOK, and the first percentile is 11 000 NOK.

Out of 11 146 firm-year observations with an accepted project, 410 firms have their R&D tax credit reduced because the sum of the R&D tax credit and other subsidies reaches a ceiling for total allowable R&D project subsidies allowed by ESA. The average tax credit reduction in this group of 410 is 36 %. 41 firm year observations have their tax credit withdrawn entirely. There is no clear statistical connection between the reduction in the R&D tax credit and direct R&D subsidies recorded in the R&D surveys.

5.4. How large is the subsidy relative to operations?

Officially, the tax credit is 18 or 20 percent of the firms' R&D spending on project supported by SkatteFUNN. However, since indirect costs are calculated based on a formula, the actual percentage may deviate when the tax credit is seen in relation to R&D in the R&D surveys.

Table 5.3 show the total R&D tax credit (intramural and extramural) in percent of total R&D as reported in the R&D surveys for firms that have received a positive tax credit and are included in the R&D surveys. We see that the average support is 0.19 percent, i.e. right "on target". For small firms – as measured by employees – the average support is somewhat larger, and for large firms somewhat smaller. This is even more evident when tabulating the support by R&D man-years in table 5.4.

Table 5.3. R&D tax credit as share of total R&D reported in the R&D surveys by firm size (number of employees)

Employees	Mean	25th percentile	Median	75th percentile	N
1-5	.30	.20	.31	.37	7
5-9	.23	.15	.20	.26	61
10-19	.22	.13	.19	.25	586
20-49	.20	.10	.17	.22	734
50-99	.19	.08	.15	.20	581
100 or more	.14	.03	.09	.17	571
All firms	.19	.08	.16	.20	2540

Table 5.4. R&D tax credit as share of total R&D reported in the R&D surveys by R&D man-years

R&D man-years	Mean	25th percentile	Median	75th percentile	N
0.1 - 0.5	.31	.16	.20	.28	126
0.5 - 1.0	.27	.15	.20	.27	188
1.0 - 2.5	.24	.14	.20	.28	682
2.5 - 5.0	.18	.11	.17	.22	689
5.0 - 10	.13	.08	.13	.17	446
10 or more	.05	.02	.03	.07	375
Total	.18	.08	.16	.20	2506

Table 5.5. R&D tax credit as share of total wage bill

Employees	Mean	25th percentile	Median	75th percentile	N
1	3.55	0.25	0.52	1.03	852
2	1.51	0.17	0.35	0.68	796
3-4	1.18	0.11	0.26	0.48	1300
5-9	0.24	0.05	0.13	0.24	1809
10-19	0.09	0.03	0.07	0.12	1801
20-49	0.04	0.01	0.03	0.05	1742
50-99	0.03	0.01	0.02	0.03	798
100 or more	0.01	0.00	0.00	0.01	650
All firms	0.66	0.02	0.07	0.23	9748

Table 5.6. R&D tax credit as share of operating profit for firms with positive profit

Employees	Mean	25th percentile	Median	75th percentile	N
1	6.71	0.21	0.59	1.62	397
2	2.40	0.22	0.54	1.26	423
3-4	2.30	0.21	0.50	1.15	754
5-9	1.89	0.11	0.29	0.83	1202
10-19	1.09	0.08	0.21	0.57	1227
20-49	0.42	0.05	0.12	0.29	1333
50-99	0.25	0.03	0.07	0.17	643
100 or more	0.08	0.00	0.02	0.06	519
All firms	1.51	0.06	0.19	0.60	6498

Table 5.3 and 5.4 are restricted to firms included in the R&D surveys. As discussed in chapter 4, these firms tend to be significantly larger than the typical firm applying for a tax credit. In tables 5.5-5.9 we relate the R&D tax credit to numbers available for all firms. The findings can be summarized as follows: For a large proportion of firms with less than 5 employees, the R&D tax credit is very large relative to the size of the firms' operations, no matter how size is measured. About 30 percent of all SkatteFUNN firms have less than 5 employees.[10] Note also that 89 % of firms with less than 5 employees get their R&D tax credit fully or partially as a subsidy, i.e. their R&D credit is larger than their tax liability. The same applies to 73% of firms with 5 or more employees that receive an R&D tax credit.

[10] The dominance of very small firms may in itself be a signal that the scheme is rather generous for this group.

Table 5.7. R&D tax credit as share of operating profit for firms with negative profit

Employees	Mean	25th percentile	Median	75th percentile	N
1	2.28	0.24	0.44	1.06	495
2	1.89	0.23	0.49	1.26	383
3-4	4.30	0.20	0.47	1.20	554
5-9	2.31	0.14	0.37	1.04	610
10-19	2.61	0.07	0.19	0.61	575
20-49	0.80	0.05	0.14	0.45	409
50-99	0.80	0.04	0.10	0.32	156
100 or more	0.15	0.01	0.03	0.11	132
All firms	2.30	0.11	0.31	0.86	3314

Table 5.8. R&D tax credit as share of total income

Employees	Mean	25th percentile	Median	75th percentile	N
1	1.98	0.07	0.19	0.51	893
2	2.80	0.05	0.13	0.34	820
3-4	0.67	0.03	0.09	0.23	1326
5-9	0.29	0.01	0.04	0.11	1841
10-19	0.25	0.01	0.02	0.05	1825
20-49	0.02	0.00	0.01	0.02	1767
50-99	0.01	0.00	0.00	0.01	814
100 or more	0.00	0.00	0.00	0.00	675
All firms	0.60	0.01	0.02	0.09	9961

Table 5.9. R&D tax credit per employee

Employees	Mean	25th percentile	Median	75th percentile	N
1	276	82	184	386	920
2	151	50	106	211	822
3-4	107	40	85	170	1336
5-9	60	20	47	90	1855
10-19	33	11	27	51	1837
20-49	14	5	13	21	1774
50-99	7	3	7	11	815
100 or more	3	1	2	4	679
All firms	72	9	29	80	10038

5.5. Reported additionality in the SkatteFUNN database

Although we follow an econometric approach to estimating the additionality effect of the SkatteFUNN, it is also interesting to look at assessments of additionality made by firms and bureaucrats. In their application to SkatteFUNN, firms must state what they think will happen to the proposed project if it is not given support through SkatteFUNN. The alternatives given are "Carried out at the same scale and time horizon", "Carried out at the same scale, but postponed", "Limited", "Postponed" or "Dropped". The firms repeat the same exercise in the final report for the project. As a part of the application processing, Innovation Norway grades projects on a scale from one to seven according to whether they believe that the project would be undertaken anyway. In the following, we take a closer look at these additionality estimates. In section 6.10, we get back to these measures and use the ex-post self-assessment of additionality together with information on reported R&D and assumptions about the quantitative degree of additionality associated with the different qualitative additionality statements to obtain one of our estimates of "the bang for the buck", i.e how much additionality that is generated per krone of forgone taxes.

Firms may submit several applications per year, and projects may span several years. To obtain unique firm-year observations of additionality in order to compare them with the firm-year observations of reported R&D, we weight the different additionality assessments of different projects in the same years with the year-specific costs share of the actual projects in the same years. In the tables below, we do not report year-specific assessments of additionality. We have carried out the same analyses by year, and results are very similar across years.

Table 5.10 reports self-reported additionality from the firms' applications. Around twelve percent of the firms stated that they would carry out the project regardless of support, while around 17 percent would postpone or drop the project. In table 5.11 we see that at for firms that actually completed a project, there is a larger fraction, around 23 percent, that states that the project would have been dropped without support. However, one should note that the firms and projects behind the two tables are different. Some projects are rejected, and some are not yet finished. There is also some degree of missing information for these variables. Table 5.12 then reports both ex ante and ex post additionality from a balanced sample, i.e. for projects where there is both ex ante and ex post self-assessment. Interestingly, the perceived additionality is larger ex post than ex ante. Fewer firms say that the project would have been carried out anyway, and more firms say that they would have dropped the projects. Comparing small and large firms in table 5.13 (where firms are classified according to the tax deduction rate in SkatteFUNN), we see that there is a slight tendency that self-reported additionality is higher among the smaller firms.

Table 5.14 shows that the distribution of grades in Innovation Norway's ex ante evaluation is quite symmetric around the middle alternative 4. In table 5.15, we compare this grading with firms' self-reported ex-post additionality. We see that there is a slight tendency that projects that Innovation Norway believed would be carried out anyway, reports lower additionality ex post.

Table 5.10. Ex ante self-reported additionality: ("What will happen to the project if it is not supported through SkatteFUNN?") Percent

Carried out at the same scale and time horizon	12
Carried out at the same scale, but postponed	14
Limited scale	52
Postponed	13
Dropped	4
Do not know	5

Table 5.11.Ex post self-reported additionality: ("What would have happened to the project if it was not supported through SkatteFUNN?") Percent

Carried out at the same scale and time horizon	13
Carried out at the same scale, but postponed	13
Limited scale	46
Postponed	15
Dropped	8
Do not know	5

Table 5.12.Ex ante and ex-post self-reported additionality. Percent

	Ex ante	Ex post
Carried out at the same scale and time horizon	16	14
Carried out at the same scale, but postponed	15	13
Limited scale	51	46
Postponed	11	15
Dropped	4	7
Do not know	4	5

Table 5.13. Ex post self-reported additionality Small and large firms. Percent

	Small firms (deduction rate 20 percent)	Large firms (deduction rate 18 percent)
Carried out at the same scale and time horizon	12	17
Carried out at the same scale, but postponed	13	13
Limited scale	46	53
Postponed	17	8
Dropped	8	5
Do not know	4	4

Table 5.14. Ex ante evaluation by Innovation Norway ("Will the project be carried out anyway?" Grades 1-7)

Grade	Percent
1	4
2	11
3	20
4	37
5	16
6	9
7	2

Table 5.15. Ex post self-reported additionality vs ex-ante evaluation by Innovation Norway

	IN grade 1-3	IN grade 4	IN grade 5-7
Carried out at the same scale and time horizon	16	12	9
Carried out at the same scale, but postponed	13	13	12
Limited scale	47	45	46
Postponed	14	15	17
Dropped	6	9	11
Do not know	4	6	4

5.6. Aggregate R&D growth

The SkatteFUNN reform was to a large extent motivated by low R&D activity in Norwegian industry and the goal of the government to increase R&D investments in the Norwegian economy from about 1.6 % of GNP to about 3 % of GDP by 2010. A successful

scheme should therefore show up in aggregate R&D investments. This is hardly the case. As seen in Figure 5.5, nominal intramural R&D investments have only had a slight increase, and it has not at all kept up with the economic growth rate. Extramural R&D has actually fallen, see Figure 5.6.

However, looking at the size of aggregate R&D tax credits relative to aggregate R&D, it also becomes clear that it would take an extreme degree of additionality for this policy instrument to move aggregate industrial R&D investments by much.

Figure 5.5. Intramural R&D for firms with ore than 10 employees

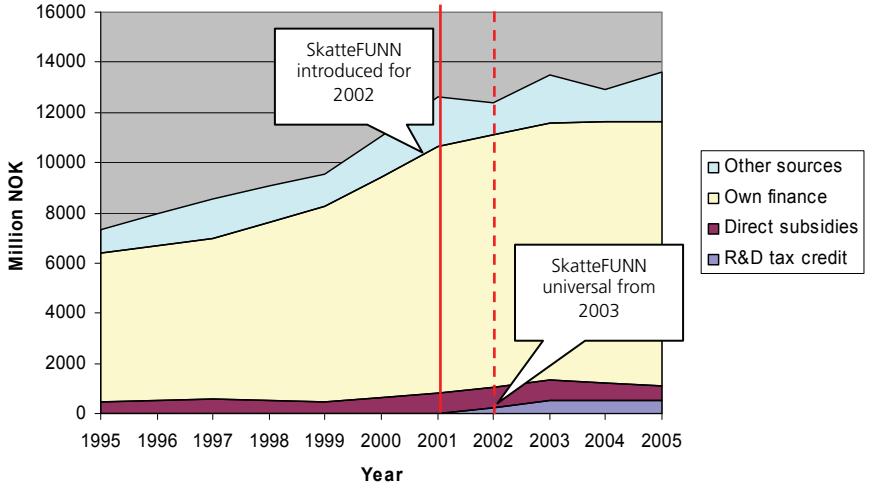


Figure 5.6. Extramural R&D for firms with more than 10 empolyees

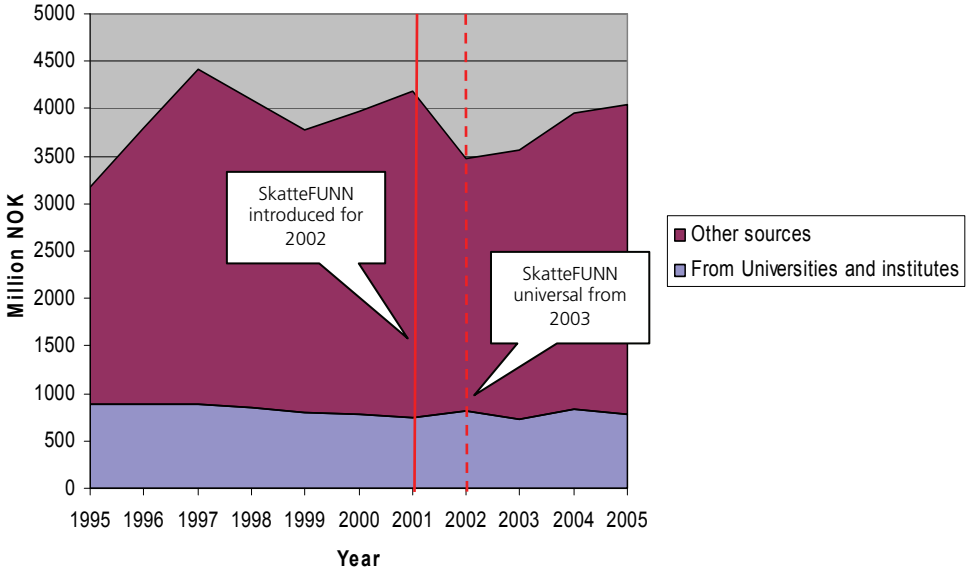


Figure 5.7. Intramural R&D for firms with 10-19 employees

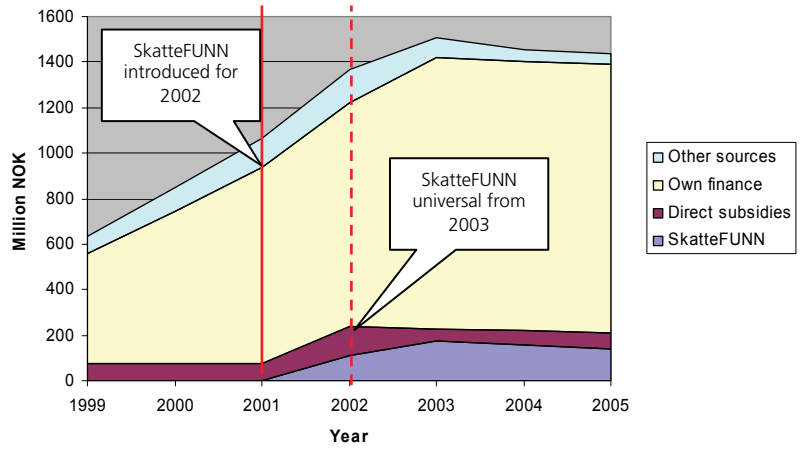
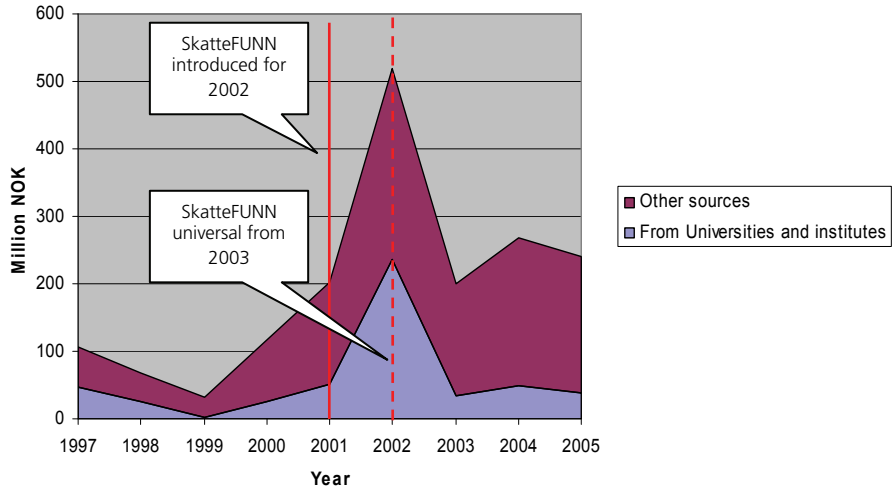


Figure 5.8. Extramural R&E for firms with 10-19 employees



Given that the tax scheme is restricted to R&D investments below 8 million, it may be more relevant to look at the aggregate R&D investments for small firms. Figure 5.7 shows aggregate intramural R&D for firms with 10-19 workers. Here, one can clearly see growth in the R&D investments from 2001 to 2003. Thereafter investments level off, but that is to be expected when firms have reached a level of R&D that is adapted to the subsidy. However, it is also evident from Figure 5.7 that the growth in R&D from 2001 to 2003 was part of a trend starting before SkatteFUNN was introduced, and it is hard do see a pattern at all in extramural R&D investments for small firms, see figure 5.8. In any case, SkatteFUNN is only one of several changes in the economic climate that may affect firms' R&D investments. A causal effect of the scheme can therefore not be identified looking only at macro data, and we will now turn to a microeconometric analysis.

6. Econometric results

6.1. Short term additionality

We start out with a simple descriptive relationship where firms' R&D investments are explained by their sales, direct R&D subsidies, a fixed effect capturing their underlying inclination to invest in R&D, year dummies capturing common macroeconomics shocks and firm specific temporary shocks such as ideas for new products and processes.

$$\ln(R\ \&\ D_{it}) = \alpha + \gamma \ln(sales_{it}) + \sum_{t=1}^{t=T} \delta_t D^{year\ t} + \eta_i + \varepsilon_{it} \quad (6.1)$$

Including firm specific fixed effects, η_i, implies that we are explaining deviations from each firm's average level of R&D. It also means that we control for all differences across firms, and hence between firms above and below the cap, that are constant over the estimation period. A change in the R&D subsidy regime like SkatteFUNN should be picked up by the year dummies as firms should do more R&D than "usual" when there is a generous subsidy regime.

Our sample consists of firms that are present in the R&D surveys and that have reported positive R&D in at least one year prior to the introduction of SkatteFUNN and that never have reported real R&D investments above 40 million NOK. Observations with R&D intensity (R&D/sales) above 5, and observations with zero R&D in the R&D surveys, but a positive R&D tax credit in the tax record are excluded. Observations that lack variables used in the analysis are also excluded. The sample period is 1993 to 2005.

The estimated coefficients are reported in table 6.1., column (1). 1993 is the base year and the year dummies represent differences in average R&D investments compared to 1993. We see that there is substantial year-to-year variation in average R&D investments, even when changes in sales are controlled for. However, there is no clear shift in the level of R&D from 2002 onwards, when SkatteFUNN was introduced. This is more clearly brought out in column (2), comparing pre- and post-SkatteFUNN years using only one coefficient.

Conditioning on sales, subsidies and firm specific levels of R&D investments, firms do not seem to invest significantly more in R&D after SkatteFUNN was introduced. This is consistent with the modest growth in aggregate R&D investments reported in figure 1.

Table 6.1, column (3) takes into account that only firms that would invest less than 4 million NOK have an incentive to increase their R&D investments in response to SkatteFUNN. Hence, equation 6.1 is expanded by interaction terms between the year dummies and a dummy for average pre SkatteFUNN R&D being below 4 million. This specification corresponds to the semi-structural equation (3.3) above with common time specific error terms and with the user price exchanged for a dummy variable that is one if a firm is eligible for a tax credit on their marginal R&D investment. We also include direct subsidies to R&D as an explanatory variable.

$$\ln(R\ \&\ D_{it}) = \alpha + \gamma \ln(sales_{it}) + \chi \ln(subsidies_{it}) + \sum_{t=1}^{t=T} \delta_t D^{aar\ t} + \sum_{t=0}^{t=T} \varphi_t D^{year\ t} \cdot D^{belowCap} + \eta_i + \varepsilon_{it} \quad (6.2)$$

As explained we do not know for sure whether a firm is eligible for a subsidy on their marginal R&D. This is because we do not know how much R&D each firm would do in absence of SkatteFUNN. We have experimented extensively with building models to predict R&D investments in absence of SkatteFUNN, and we have concluded that it is difficult to do much better than using the latest R&D observation prior to SkatteFUNN although there is some information in earlier R&D observations also. As explained in chapter 3.1, however, using only the latest R&D observation will imply a regression-to-the-mean bias. To avoid this, we base the classification on the average level of R&D prior to SkatteFUNN. This predicts future R&D almost as well as using the latest observation only. Hence, $D^{below\ cap}$ in equation 6.2 is one if a firm on average invested less than 4 million in R&D in those of the years 1993 to 2001 when it was observed.[11]

[11] The comparison is based on real R&D investments in 2003 NOK. See chapter 4.

Table 6.1. Short term additionality of SkatteFUNN

	(1)	(2)	(3)	(4)
ln(sales)	0,375***	0,379***	0,365***	0,367***
	(0,119)	(0,112)	(0,117)	(0,118)
ln (direct subsidies)	0,367***	0,368***	0,361***	0,363***
	(0,022)	(0,022)	(0,022)	(0,022)
Dummy for 1995	0,427**		0,157	0,443**
	(0,190)		(0,315)	(0,189)
Dummy for 1997	0,417*		-0,025	0,433*
	(0,224)		(0,437)	(0,223)
Dummy for 1999	-0,167		-0,299	-0,152
	(0,227)		(0,432)	(0,226)
Dummy for 2001	0,808***		-0,079	0,813***
	(0,222)		(0,403)	(0,222)
Dummy for 2002	0,456**		-0,369	-0,095
	(0,224)		(0,405)	(0,268)
Dummy for 2003	0,809***		-0,419	0,239
	(0,228)		(0,420)	(0,276)
Dummy for 2004	0,934***		-0,008	0,359
	(0,233)		(0,428)	(0,276)
Dummy for 2005	0,293		-0,927**	-0,276
	(0,240)		(0,441)	(0,286)
Post SkatteFUNN year		0,259**		
		(0,105)		
Dummy for 1995 * below 4 mill			0,419	
			(0,388)	
Dummy for 1997 * below 4 mill			0,635	
			(0,504)	
Dummy for 1999 * below 4 mill			0,249	
			(0,500)	
Dummy for 2001 * below 4 mill			1,195**	
			(0,477)	
Dummy for 2002 * below 4 mill			1,116**	
			(0,481)	
Dummy for 2003 * below 4 mill			1,655***	
			(0,494)	
Dummy for 2004 * below 4 mill			1,264**	
			(0,500)	
Dummy for 2005 * below 4 mill			1,643***	
			(0,512)	
Post SkatteFUNN year * below 4 mill				0,755***
				(0,219)
Constant term	0,105	0,402	0,188	0,189
	(1,344)	(1,289)	(1,320)	(1,332)
Adj R-sq (within)	0,074	0,061	0,079	0,077
No. of obs.	8233	8233	8233	8233

The dependent variable is ln(intramural R&D). All specifications include firm fixed effects.

Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Looking at column (3) we find that the year dummies for the firms that on average invested less than 4 million before SkatteFUNN, are larger after the introduction of SkatteFUNN. Column (4) makes this even clearer, when the dummy for pre SkatteFUNN R&D being below 4 million is interacted with a single dummy for post SkatteFUNN years. The results in column (4) correspond to the two group comparison done in chapter 3.1. We see that firms below the cap – those that have their marginal cost of R&D investments reduced – have larger R&D investments after the introduction of SkatteFUNN than firms above the cap. The coefficient is significant at the 1 percent level. The point estimate of 0.755 log points imply a little more than a doubling of R&D investments. This result suggests that SkatteFUNN strongly stimulate firms' R&D investments. However, like the two group comparison, this interpretation build on the assumption that there are no other macroeconomic changes that affect firms above and below the cap differently[12]. Furthermore, the effect is largely driven by firms that in some years prior to SkatteFUNN have reported zero R&D and in some years positive R&D. Hence the high growth is typically from a very low level. If we only include firms that always report positive R&D, the estimated coefficient becomes slightly negative and insignificant. If we include these firms, but treat zero R&D as missing – one might suspect that this is the case for some of the observations – we get a coefficient that is substantially reduced. If, on the other hand we include all firms in the R&D surveys, also those that never reported R&D prior to SkatteFUNN, the estimated coefficient increases.

[12] One such effect is that firms that do more than 4 million in intramural R&D but less than 8 million in total R&D may have an incentive to substitute intramural R&D for extramural R&D.

Table 6.2. Short term additionality of SkatteFUNN, controlling for participation in the scheme

	(1)	(2)	(3)	(4)
Dependent variable	ln(intramural R&D)	ln(intramural R&D)	ln(R&D man-years)	ln(R&D man-years)
ln(sales)	0,325***	0,328***	0,321***	0,324***
	(0,112)	(0,113)	(0,114)	(0,115)
Ln(direct subsidies)	0,358***	0,359***	0,336***	0,337***
	(0,022)	(0,022)	(0,022)	(0,022)
Dummy for 1995	0,157	0,434**	0,095	0,425**
	(0,314)	(0,188)	(0,306)	(0,192)
Dummy for 1997	-0,050	0,433*	-0,107	0,367
	(0,435)	(0,221)	(0,429)	(0,224)
Dummy for 1999	-0,301	-0,147	-0,248	-0,147
	(0,431)	(0,224)	(0,427)	(0,229)
Dummy for 2001	-0,032	0,857***	-0,061	0,878***
	(0,398)	(0,219)	(0,391)	(0,223)
Dummy for 2002	-0,544	-0,184	-0,456	-0,057
	(0,409)	(0,287)	(0,410)	(0,294)
Dummy for 2003	-1,105**	-0,467	-0,982**	-0,368
	(0,459)	(0,311)	(0,459)	(0,317)
Dummy for 2004	-0,708	-0,418	-0,505	-0,233
	(0,463)	(0,308)	(0,464)	(0,315)
Dummy for 2005	-1,528***	-0,795**	-1,354***	-0,602*
	(0,473)	(0,315)	(0,479)	(0,323)
Dummy for 1995 * below 4 mill	0,408		0,477	
	(0,386)		(0,385)	
Dummy for 1997 * below 4 mill	0,665		0,657	
	(0,501)		(0,499)	
Dummy for 1999 * below 4 mill	0,259		0,195	
	(0,498)		(0,499)	
Dummy for 2001 * below 4 mill	1,192**		1,258***	
	(0,471)		(0,470)	
Dummy for 2002 * below 4 mill	0,927*		0,826*	
	(0,485)		(0,491)	
Dummy for 2003 * below 4 mill	1,312**		1,126**	
	(0,533)		(0,537)	
Dummy for 2004 * below 4 mill	0,848		0,668	
	(0,535)		(0,541)	
Dummy for 2005 * below 4 mill	1,439***		1,310**	
	(0,543)		(0,554)	
SkatteFUNN	1,498***	1,453***	1,415***	1,394***
	(0,253)	(0,222)	(0,256)	(0,225)
SkatteFUNN * below 4 mill	1,282***	1,331***	1,352***	1,370***
	(0,298)	(0,259)	(0,303)	(0,263)
Post SkatteFUNN year * below 4 mill		0,445*		0,288
		(0,260)		(0,267)
Constant	0,619	0,618	-6,101***	-6,103***
	(1,265)	(1,278)	(1,284)	(1,299)
Adj R-sq (within)	0,132	0,130	0,119	0,117
No. of obs.	8233	8233	8233	8233

The dependent variable is ln(intramural R&D) in column (1) and (2) and ln(intramural R&D man-years) in column (3) and (4). All specifications include firm fixed.

* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

Following the international literature summarized in chapter 3.2, we use the natural log of R&D as our left hand side variable. Since the log of zero is not determined, a specific choice must be made regarding how to treat observations with zero R&D. The standard way to get around this problem is to set ln(R&D) equal to zero for firms with no R&D. In our case this is the same as assuming that firms reporting no formal R&D actually invest 1000 NOK on R&D "informally". When these observations turn out to drive the magnitude of the results, we should be careful not to interpret the coefficients literally as their size will be sensitive to this choice.

Many of the firms classified as having an incentive to increase their R&D investments do not use the SkatteFUNN tax credit. Hence, comparing growth rates among those firms that self-select into the scheme also has some interest. Again, we would expect firms below the cap to have larger growth in R&D investments than those above the cap, and due to the selection process, we expect to see larger coefficients for both groups. The specification we use is

(6.3)

$$\ln(R\,\&\,D_{it}) = \alpha + \gamma \ln(sales_{it}) + \chi \ln(subsidies_{it}) + \sum_{t=1}^{t=T} \delta_t D^{\text{year } t} + \sum_{t=0}^{t=T} \varphi_t D^{\text{year } t} \cdot D^{belowCap} + \theta SF + \beta SF \cdot D^{belowCap} + \eta_i + \varepsilon_{it}$$

The results are reported in table 6.2.

We see that all firms do more R&D than they usually do when they receive support from SkatteFUNN, since the coefficient for the SkatteFUNN variable is

significantly positive. This is most likely a selection effect: Firms with a good research idea self-select into the scheme. More importantly, for firms that used to do less than 4 million R&D prior to SkatteFUNN the positive effect is much larger, since for these firms the SkatteFUNN "effect" is the sum of the coefficients for the SkatteFUNN and SkatteFUNN * below 4 mill. Assuming that the former captures a common self-selection effect, the latter is an estimate of the increase that is due to the tax credit itself. Interestingly, those that used to do less than 4 million R&D and that do not apply for SkatteFUNN support increase their reported R&D more than those above the cap that did not apply, although this difference is only weakly significant when we measure R&D as intramural R&D and insignificant when R&D man-years is our dependent variable. This casts some doubt on the results. One might e.g. worry that some of the reported zeros prior to SkatteFUNN are not true, and that the data quality is better in more recent years. This would give such an effect.

6.2. Long term additionality

Our results are consistent with SkatteFUNN having positive additionality, although the growth seems to be most strongly associated with firms that did very little R&D prior to SkatteFUNN. An interesting follow-up question is whether the effect is stronger in the long run than in the short run. This is plausible, as there may be some fixed and irreversible costs associated with building up research capacity in firms. On simple way to assess this question within the regression framework used in table 6.2 is to add terms for the first year a firm receives support from SkatteFUNN. If the effect increases over time we should see a negative coefficient on the first year variable for firms that are below the cap. This is tested in table 6.3. The specification is similar to the one in table 6.2, column (2), and adds interaction terms between the SkatteFUNN dummies and whether a firm receives support for the first time. The coefficient is close to zero and insignificant.

Table 6.3. Specific coefficients for the first year with support

Dependent variable	ln(intramural R&D)
SkatteFUNN	1,386***
	(0,224)
SkatteFUNN * below 4 mill	1,357***
	(0,273)
SkatteFUNN, first year	-0,150
	(0,145)
SkatteFUNN, first year * below 4 mill	0,105
	(0,173)
Adj R-sq (within)	0.117
No. of obs.	8233

The constant term, ln (sales), ln (direct subsidies), a post SkatteFUNN year dummy and interacted with "below 4 mill" are not reported. The sample and specification is identical to table 6.2, except for the two first-year variables.

* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

Table 6.4. Two and four year R&D growth rates for SkatteFUNN firms

	Growth 2001-2003	Growth 2001-2005
Sales growth	-0,441	0,578
	(0,380)	(0,359)
Growth in subsidies	0,204***	0,261***
	(0,058)	(0,066)
Dummy for below 4 mill	-0,526	-0,043
	(0,489)	(0,593)
SkatteFUNN 2003	1,841***	2,550***
	(0,579)	(0,698)
SkatteFUNN 2003 * below 4 mill	1,946***	0,638
	(0,692)	(0,836)
No. of obs.	616	616

The dependent variables are log differences in intramural R&D. The estimation method is censored normal regression.

* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

Table 6.5. Dynamic specification

ln(intramural $R\&D_{t-2}$)	0,102**
	(0,041)
ln(sales)	0,128
	(0,254)
ln (direct subsidies)	0,306***
	(0,040)
Dummy for 2001	-0,404
	(0,555)
Dummy for 2003	-1,214
	(0,920)
Dummy for 2005	-1,693
	(1,254)
Dummy for 1999 * below 4 mill	-0,735
	(0,461)
Dummy for 2001 * below 4 mill	0,579
	(0,510)
Dummy for 2003* below 4 mill	1,001*
	(0,596)
Dummy for 2005* below 4 mill	0,802
	(0,603)
SkatteFUNN	1,390***
	(0,421)
SkatteFUNN* below 4 mill	0,758
	(0,512)
Constant	0,069
	(0,355)
No. of obs.	1643

The dependent variable is ln(intramural R&D). All specification include a firm fixed and is estimated using the Anderson and Hsiao (1982) methodology..

* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

An alternative way to assess the long run effect of SkatteFUNN is to look explicitly at short term growth rates vs long run growth rates. In table 6.4 this is done for the 616 firms within our main sample that are observed both in 2001, 2003 and 2005.

Once again there is little to indicate that the long run effects are larger than the short run effects. Actually, the growth from 2001 to 2003 is larger than the growth from 2001 to 2005 for SkatteFUNN firms below the cap.

A third way to assess the long run effect is to use a dynamic specification explicitly modelling that previous R&D affects present R&D. This can be done by including previous R&D as an explanatory variable.

Combining a lagged dependent variable with a fixed effect demands an instrumental variable technique. The "state of the art" is to use the Arellano-Bond (1991) GMM estimator. However, this estimator is constructed for situations with annual observations. For most of our sample, R&D information is only available every second year. This is easily handled with two stage least squares, the standard approach prior to Arellano and Bond. Following Anderson and Hsiao (1982) we use the first difference transformation to control for the fixed effects, and then use $lnR\&D_{t-4}$ and $lnR\&D_{t-6}$ as instruments for $\Delta lnR\&D_{t-2}$. The results are presented in table 6.5. We see that lagged R&D two years back has significant explanatory power. In order to simplify the calculations, we may assume that the firms enter SkatteFUNN permanently in a year not included in the sample. The coefficient 0.102 then implies that long term effect of SkatteFUNN is 0.758/(1-0.102)=0.844, i.e. 8 percent larger than the short term effect. From a theoretical point of view, this specification is our preferred one. However, since only observations observed every second year, six times in a row can be included, a lot of observations cannot be used, and many of these observations will be from small firms.

6.3. The probability to start or continue R&D

In the main analysis we have left out firms that never invested in R&D prior to SkatteFUNN, arguing that the decision to start doing R&D for the first time is different from deciding how much R&D to do given that the firm has some R&D experience. In this chapter we analyze the probability of starting to do R&D given that one did not do R&D two years earlier. We also analyze the probability of continuing to do R&D given that one did R&D two years earlier. The results are reported in table 6.6.

We find that in the years 2003 and 2004, i.e. after SkatteFUNN was introduced, firms that did not do R&D two years earlier had a 6-7 percentage points higher probability of starting to do R&D as compared to the years 1995-2001. This is consistent with SkatteFUNN being successful in stimulating increased R&D activities in small firms. It is interesting to note that this is not the case in 2005. Firms that did not do R&D in 2003 – when SkatteFUNN was available – had a lower probability of starting to do R&D as compared to the probability in the years 1995-2001. Our interpretation is that this is a selected group of firms with particularly low probability of starting to do R&D. The pool of potential R&D firms among those that did not do R&D seems to be exhausted quickly after the scheme is introduced.

Looking next at the probability of continuing to do R&D, given that a firm did R&D two years ago, we find that this probability is 10-16 percentage points higher in the years after SkatteFUNN was introduced. Here the effect of SkatteFUNN is permanent.

Table 6.6. The probability of starting or continuing R&D

	Intramural $R\&D_{t-2}=0$	Intramural $R\&D_{t-2}>0$
ln(sales)	0,036***	0,045***
	(0,008)	(0,014)
$ln(sales)_{t-2}$	-0,004	-0,004
	(0,008)	(0,013)
Dummy for 2003†	0,104***	0,133***
	(0,014)	(0,015)
Dummy for 2004†	0,073***	0,160***
	(0,016)	(0,014)
Dummy for 2005†	-0,017	0,072***
	(0,011)	(0,015)
Pseudo R-sq	0,088	0,087
No. of obs.	7286	3851

† Marginal effect for discrete change of the dummy variable from 0 to 1. The years 1995-2001 is absorbed by the constant term and not reported.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Table 6.7. Effects on R&D cooperation

	Extramural R&D from research institutions $R\&D_{t-2}=0$	Extramural R&D from research institutions $R\&D_{t-2}>0$
ln(sales)	0,023***	0,051**
	(0,004)	(0,026)
$ln(sales)_{t-2}$	-0,002	0,008
	(0,004)	(0,025)
Dummy for 2003†	0,024***	-0,017
	(0,007)	(0,043)
Dummy for 2004†	0,012*	0,014
	(0,007)	(0,045)
Dummy for 2005†	-0,010**	-0,085**
	(0,005)	(0,038)
Pseudo R-sq	0,106	0,072
No. of obs.	9795	1316

† Marginal effect for discrete change of the dummy

6.4. The probability to start or continue R&D cooperation

SkatteFUNN is designed with a special focus to encourage R&D done in cooperation with universities, colleges and research institutes. For this type of R&D the cap is 8 million, i.e. firms that do 4 million intramural R&D can receive a tax credit for an additional 4 million extramural R&D done in cooperation with universities, colleges and research institutes. If they do less than 4 million intramural R&D they can transfer the unspent quota and get a tax credit for cooperative projects with a budget up to 8 million.In this section we analyzed the probability to start or continue such cooperative R&D.

Table 6.7, column (1), looks at the probability to start buying R&D from research institutions for firms that did not do so two years earlier. We see that there is some evidence suggesting that this probability has increased after the introduction of SkatteFUNN with a positive and significant coefficient in 2003 and 2004. The effect levels off, and in 2005 the coefficient is significantly negative. For all years the size of the effect is small, about 1-2 percentage points evaluated for mean values of the other variables. Moving on to column (2), using a sample of firms that *did* buy R&D

from universities, colleges and research institutes two years earlier, we see that there is no evidence to suggest that the probability to continue to buy such R&D increased for this group after the introduction of SkatteFUNN.

Taken together, the data does not suggest that SkatteFUNN has had a large impact on the incentive to buy R&D from universities, colleges and research institutes. We will return to this issue in section 6.9.

6.5. Estimates based on historic R&D reported in the SkatteFUNN database

Perhaps the major data problem in the evaluation of the SkatteFUNN scheme is that a disproportionately large share of the R&D projects supported by the SkatteFUNN scheme is carried out by small firms, e.g. firms with less than five or ten employees, cf. chapter 4. Historically, these firms are not covered well by the R&D surveys. Therefore we have little direct and independent information of the R&D activity of these firms prior to the launching of the SkatteFUNN scheme. However, information about these firms has been collected as part of the application process. To what extent this information is reliable is an open question. These data have not previously been used for any analytic purpose. R&D variables are reported for up to three years after the R&D in question was conducted – and the firms may report strategically in a way they think benefits their application. In general, the results confirm our findings above, and the quality of the data seems surprisingly high.

In the SkatteFUNN application, firms must state their level of R&D investments in the three previous years. In principle, this information is just as "valid" as the information of firms' R&D investment from the R&D survey. However, the R&D surveys are collected about 6 months after the investment year, independently year by year, and the numbers are revised by Statistics Norway. In the SkatteFUNN application, firms are asked for information up to three years back in time, all at once, and the reported numbers are not of direct relevance to the application. Moreover, the R&D surveys are conducted independent of SkatteFUNN, while the information in the SkatteFUNN scheme is given in a particular setting. Firms may think strategically in terms of maximizing the probability of receiving support through the tax credit scheme. This may possibly bias the self-reported previous R&D investments. However, the direction of such a bias is not obvious. Firms may think that a high level of previous R&D may signal high R&D capability, thereby giving extra credibility to the application. They may also think that since one of the main goals of the scheme is to increase overall R&D, stating a low level of R&D will all else equal increase the chance of approval. We regard the information of previous R&D from the applications to be of lower quality than that from the R&D survey, but the direction and magnitude of bias is not clear.

Since SkatteFUNN was introduced in 2002, R&D information from applications dates back to 1999 at the earliest. Many firms have submitted several applications, both within the same year and in consecutive years. This means that there may be several observations of R&D for the same firm and year. In many cases, the figures are non-corresponding. For each firm and year, we have used the average of all the stated levels of R&D as our measure of historical R&D investments. For the years where firms actually carried out SkatteFUNN projects, we have used the level of R&D submitted to and approved by the tax authorities. For firms with high R&D, this measure may be downward biased, as there is no incentive to report more than the maximum level of R&D eligible for tax deduction (4 millions for intramural R&D). In fact, we see that there is a tendency of a clustering around 4 millions, but it is not large, and many firms report R&D that is well above this level. However, this is likely to bias the post SkatteFUNN changes in R&D for large R&D firms downward.

Contrary to the sample based on the R&D surveys, the SkatteFUNN database consists only of firms that have applied for support through SkatteFUNN. The majority of them have also received support. Implicitly, the questions we attempt to answer in our econometric analyses are then slightly different: Have SkatteFUNN increased the R&D of *these firms* after the scheme was introduced? Is this increase higher in the years when they actually get support from SkatteFUNN? We use the same econometric specifications, i.e. variations of equation (6.1) and (6.2), and the same basic sample criteria as in the main analysis based on the R&D surveys. As for the interpretation of the results, the challenges related to selection bias still apply, and there is an additional dimension since the sample of firms are those who have chosen to apply for support through SkatteFUNN. Even if the main information is taken from another sample, covering an important part of the population of firms, the additionality estimates we obtain are *not* independent from the ones reported above, since the new dataset does not help us in resolving the fundamental problem associated with identifying the true effect of SkatteFUNN.

Table 6.8. Short term additionality of SkatteFUNN

	(1)	(2)	(3)	(4)
Constant term	1.914***	2.541***	2.121***	2.693***
	(0.200)	(0.201)	(0.196)	(0.198)
ln(sales)	0.237***	0.317***	0.214***	0.300***
	(0.022)	(0.022)	(0.021)	(0.022)
Dummy for 2000	0.858***		0.469**	
	(0.070)		(0.198)	
Dummy for 2001	1.782***		0.741***	
	(0.066)		(0.187)	
Dummy for 2002	2.049***		0.552***	
	(0.066)		(0.186)	
Dummy for 2003	2.330***		0.160	
	(0.066)		(0.187)	
Dummy for 2004	2.362***		-0.144	
	(0.069)		(0.191)	
Dummy for 2005	2.384***		-0.159	
	(0.074)		(0.197)	
Post SkatteFUNN year		0.930***		-0.575***
		(0.030)		(0.080)
Dummy for 2000 * below 4 mill			0.418**	
			(0.211)	
Dummy for 2001 * below 4 mill			1.191***	
			(0.199)	
Dummy for 2002 * below 4 mill			1.723***	
			(0.198)	
Dummy for 2003 * below 4 mill			2.483***	
			(0.199)	
Dummy for 2004 * below 4 mill			2.889***	
			(0.204)	
Dummy for 2005 * below 4 mill			2.963***	
			(0.211)	
Post SkatteFUNN year * below 4 mill				1.731***
				(0.086)
Observations	14831	14831	14831	14831
Number of firms	3264	3264	3264	3264
R-squared (within)	0.17	0.11	0.20	0.14

This table corresponds to table 6.1. The dependent variable is ln(intramural R&D). All specifications include firm fixed effects.

* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

Table 6.8 corresponds directly to table 6.1, but the base year is 1999 and the year dummies in columns (1) and (3) represent differences in average R&D investments compared to 1999. We see that there is a clear trend within the sample of SkatteFUNN firms that the level of R&D investments increases over time, but it is not obvious from column (1) that there was a clear shift around the introduction of the scheme. In column (3) and (4) we take into account that only those that would otherwise invest less than 4 millions have incentives on the margin to increase their level of R&D in response to SkatteFUNN. Similar to the main analysis, we use average R&D prior to SkatteFUNN as our predictor for R&D investments in absence of the scheme. It is very clear that the year dummies for the firms that on average invested less than 4 millions before SkatteFUNN are much larger for the years after the introduction. Abstracting from single years in column (4) makes this even clearer. The results strongly suggest that firms who have incentives to increase their R&D because of SkatteFUNN actually do so. The estimated additionality effect is even larger than what is reported in table 6.1, but this may partly reflect that the effect is to a large extent driven by firms that did very little R&D prior to SkatteFUNN, and that there are relatively more such firms in this sample than in the sample from the R&D surveys.

In table 6.9, which corresponds closely to table 6.2., we allow the effects to vary not only with the existence of SkatteFUNN, but with actual use of the scheme (in a given year). We do the analysis both on the full sample of applicants (columns 1 and 2), and on the sample of firms who have received support from the scheme (column 3 and 4). The results are very similar across samples. Firms who invested less than 4 millions before SkatteFUNN, increase their investments after the scheme was introduced, even in the years when they did not receive any support. The coefficient is (0.349+0.019) in column (4). However, the increase is much stronger in the years that they actually received support (1.868+0.681). It is interesting to note that for firms with prior investment above the cap, the introduction of the scheme did not seem to have any effect, while the investments appear to have been reduced in the years that they used SkatteFUNN. This effect is probably related to the different reporting of prior and current R&D as discussed above.

Our identification strategy relies upon the assumption that the incentives in SkatteFUNN differ fundamentally below and above the cap. In table 6.10, we therefore experiment with sample restrictions that are tighter around the cap of 4 million kroner. Comparing column (1) and column (2), we see that the high additionality

estimate is largely driven by firms that conducted very little R&D before SkatteFUNN, but the estimate in column (2) still amounts to more than a doubling. Column (3) and (4) narrow the sample even more. The effect is still positive, though more modest. This may reflect that the incentives to increase R&D are weaker closer to the cap, and that it is harder to predict firms over or below the cap the closer their "true level" is to the cap.

Table 6.9. Short term additionality of SkatteFUNN, controlling for participation in the scheme

	(1)	(2)	(3)	(4)
Constant term	2.258***	2.955***	2.937***	3.488***
	(0.193)	(0.194)	(0.209)	(0.212)
ln(sales)	0.216***	0.271***	0.217***	0.279***
	(0.021)	(0.021)	(0.022)	(0.023)
Dummy for 2000	0.515***		0.508***	
	(0.195)		(0.196)	
Dummy for 2001	0.844***		0.859***	
	(0.185)		(0.186)	
Dummy for 2002	0.925***		0.965***	
	(0.196)		(0.200)	
Dummy for 2003	0.781***		0.845***	
	(0.218)		(0.225)	
Dummy for 2004	0.611***		0.675***	
	(0.235)		(0.242)	
Dummy for 2005	0.584**		0.605**	
	(0.238)		(0.244)	
Post SkatteFUNN year		-0.058		-0.019
		(0.130)		(0.141)
Dummy for 2000 * below 4 mill	0.327		0.326	
	(0.208)		(0.210)	
Dummy for 2001 * below 4 mill	0.912***		0.955***	
	(0.197)		(0.199)	
Dummy for 2002 * below 4 mill	0.782***		0.594***	
	(0.209)		(0.214)	
Dummy for 2003 * below 4 mill	1.135***		0.701***	
	(0.231)		(0.240)	
Dummy for 2004 * below 4 mill	1.229***		0.784***	
	(0.250)		(0.259)	
Dummy for 2001 * below 4 mill	1.275***		0.913***	
	(0.255)		(0.262)	
Post SkatteFUNN year * below 4 mill		0.556***		0.349**
		(0.137)		(0.151)
SkatteFUNN	0.707***	0.648***	0.740***	0.681***
	(0.132)	(0.132)	(0.138)	(0.139)
SkatteFUNN * below 4 mill	1.636***	1.710***	1.945***	1.868***
	(0.141)	(0.140)	(0.148)	(0.149)
Observations	14831	14831	11748	11748
Number of group(org_nr)	3264	3264	2243	2243
R-squared	0.23	0.18	0.26	0.20

This table corresponds to table 6.1. Standard errors in parentheses. The dependent variable is ln(intramural R&D). All specifications include firm fixed effects. The last two columns are restricted to those who have ever used SkatteFUNN.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.10. Short term additionality of SkatteFUNN by pre SkatteFUNN R&D investment level

	(1)	(2)	(3)	(4)
Constant	3.284***	5.297***	5.752***	5.339***
	(0.216)	(0.249)	(0.359)	(0.627)
Ln(sales)	0.288***	0.229***	0.213***	0.264***
	(0.024)	(0.026)	(0.037)	(0.063)
SkatteFUNN	-0.439***	-0.427***	-0.317**	-0.184
	(0.166)	(0.131)	(0.157)	(0.232)
SkatteFUNN*below 4 mill	1.625***	0.875***	0.612***	0.374
	(0.174)	(0.150)	(0.194)	(0.300)
Post SkatteFUNN year	-0.018	-0.015	0.021	0.091
	(0.167)	(0.132)	(0.159)	(0.234)
Post SkatteFUNN year *below 4 mill	0.346**	0.050	-0.129	-0.356
	(0.176)	(0.152)	(0.197)	(0.303)
Observations	11276	4966	2431	1031
Number of group(org_nr)	2151	922	441	188
R-squared	0.20	0.06	0.03	0.02
Mean pre R&D	<10 mill	>1 mill,<10 mill	>2 mill, <6 mill	>3 mill, <5 mill

Standard errors in parentheses. The dependent variable is ln(intramural R&D). All specifications include firm fixed effects.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.11. Short term additionality of SkatteFUNN by pre SkatteFUNN R&D investment level.

	(1)
ln(sales)	0.280***
	(0.022)
Post SkatteFUNN year *(0-1 mill)	0.586***
	(0.150)
Post SkatteFUNN year *(1-2 mill)	0.170
	(0.179)
Post SkatteFUNN year *(2-3 mill)	-0.018
	(0.227)
Post SkatteFUNN year *(3-4 mill)	-0.248
	(0.274)
Post SkatteFUNN year	-0.019
	(0.137)
SkatteFUNN*(0-1 mill)	2.294***
	(0.148)
SkatteFUNN *(1-2 mill)	1.244***
	(0.175)
SkatteFUNN *(2-3 mill)	1.021***
	(0.224)
SkatteFUNN *(3-4 mill)	0.870***
	(0.271)
SkatteFUNN	-0.681***
	(0.135)
Constant	3.470***
	(0.205)
	Ord sample + ever used
Observations	11748
Number of group(org_nr)	2243
R-squared	0.25

Standard errors in parentheses. The dependent variable is ln(intramural R&D). All specifications include firm fixed effects.

* significant at 10%; ** significant at 5%; *** significant at 1%

The findings from table 6.10 suggest that the additionality effects may differ with the "distance to the cap". We explore this further in table 6.11, and the findings correspond well with the previous table. The large average additionality effect is largely driven by firms with low previous R&D investments, where a given increase in kroner corresponds to a large relative increase. However, this specification again highlights the problems created by the likely underreporting of R&D investments (after SkatteFUNN) to the tax authorities from large R&D performers. This poses a challenge for our difference-in-difference approach, overestimating the additionality effect for those below the cap, since the benchmark growth rate is not measured correctly. We therefore report the result from a slightly different exercise in table 6.12. Here we compare R&D investments for SkatteFUNN firms in years when they participate in SkatteFUNN to years when they do not participate, but SkatteFUNN exists. Compared to the specification used in most of this report, we then do not isolate the assumed common effect of self-selection into the scheme. (The estimate is a "difference", not a "difference-in-difference".) This probably biases the estimates upward. On the other hand, we do not rely on underreported R&D for the firms above the cap when we estimate the effect below the cap, which would also bias estimates upward. The estimated additionality for firms below the cap is smaller than what is found in table 6.11.

Table 6.12: Short term additionality of SkatteFUNN by pre SkatteFUNN R&D investment level. "Difference approach"

	(1)	(2)
Constant	3.490***	5.771***
	(0.205)	(0.360)
ln(sales)	0.278***	0.211***
	(0.022)	(0.037)
Post SkatteFUNN year *(0-1 mill)	0.567***	
	(0.063)	
Post SkatteFUNN year *(1-2 mill)	0.151	
	(0.115)	
Post SkatteFUNN year *(2-3 mill)	-0.037	-0.021
	(0.180)	(0.146)
Post SkatteFUNN year *(3-4 mill)	-0.267	-0.257
	(0.237)	(0.191)
Post SkatteFUNN year *(4-5 mill)	0.095	0.078
	(0.287)	(0.231)
Post SkatteFUNN year *(5-6 mill)	-0.090	-0.074
	(0.271)	(0.219)
Post SkatteFUNN year * (more	-0.036	
than 6 mill)	(0.190)	
SkatteFUNN*(0-1 mill)	1.612***	
	(0.061)	
SkatteFUNN *(1-2 mill)	0.563***	
	(0.112)	
SkatteFUNN *(2-3 mill)	0.340*	0.354**
	(0.179)	(0.144)
SkatteFUNN *(3-4 mill)	0.189	0.193
	(0.234)	(0.189)
SkatteFUNN *(4-5 mill)	-0.190	-0.161
	(0.284)	(0.229)
SkatteFUNN *(5-6 mill)	-0.503*	-0.485**
	(0.266)	(0.214)
SkatteFUNN * (more than 6 mill)	-0.991***	
	(0.188)	
	Ord sample + ever used	2-6 + ever used
Observations	11748	2431
Number of group(org_nr)	2243	441
R-squared	0.26	0.04

Standard errors in parentheses. The dependent variable is ln(intramural R&D). All specifications include firm fixed effects.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.13. Short term additionality results by data source for matched sample

	All data from SkatteFUNN base	All data from R&D survey
Ln(sales)	-0.240**	-0.084
	(0.097)	(0.139)
Post SkatteFUNN year	-0.213	0.425**
	(0.179)	(0.198)
Post SkatteFUNN year	0.516**	0.893***
*below 4 mill	(0.211)	(0.245)
SkatteFUNN	-0.741***	-0.525**
	(0.176)	(0.225)
SkatteFUNN*below 4 mill	1.341***	1.015***
	(0.208)	(0.274)
Constant	10.051***	7.630***
	(1.090)	(1.570)
Observations	1873	1873
Number of groups (org_nr)	489	489
R-squared	0.14	0.17

Standard errors in parentheses. The dependent variable is ln(intramural R&D). All specifications include firm fixed effects.

* significant at 10%; ** significant at 5%; *** significant at 1%

As a final analysis, table 6.13 reports the results from regressions on the sample of firms that are both in the R&D survey-based sample used in section 6.1-6.4, and

in the sample based on the SkatteFUNN database in this section. In one of the specifications, all the variables are taken from the SkatteFUNN base, whereas the other only uses variables from the R&D surveys. As seen from the table, the two datasets yield quite similar, though far from identical results. The most striking difference is that the estimated "additionality effect" for firms below the cap is higher when we use R&D figures from the SkatteFUNN application as our measure of R&D. Again this could be due to the underreporting for the large firms as discussed above. Note that the sums of the coefficients for the SkatteFUNN and the SkatteFUNN*less than 4 mill variables are quite similar across datasets.

6.6. Effects of SkatteFUNN on employment and production reported in public registers

What we have found so far is basically that firms report more R&D when they receive the tax credit. However, with a tax credit proportional to R&D spending, firms that receive a tax subsidy on their marginal R&D investment have an obvious incentive to include as many costs as possible in their R&D budgets. This incentive was not present before the introduction of SkatteFUNN. In theory, therefore, the increase in R&D investments we have estimated so far could simply reflect a change in firms' way of reporting R&D – possibly legitimate, possibly illegitimate. Another possible mechanisms going in the same direction is that the tax credit increases the demand for researchers. If this demand is inelastic, the tax credit would mainly cause the wage of researchers to rise. Hence, real R&D costs would increase, but not real R&D efforts.

If firms increase their true R&D efforts, it should be possible to observe this in firms' labour productivity. R&D-activities are labour intensive, and typically, the returns to the investments materialize after the fiscal year when the R&D is undertaken. Therefore, either, labour inputs should increase for a given production level, or production should fall for a given labour input.

Data on labour use and production (sales) can be extracted from administrative registers. These data are collected independent of firms' reporting of R&D. If effects of the tax credit can be found in these numbers it would add significant credibility to our conclusion that the tax credit stimulates additional R&D.

Based on individual register data from 1997-2004 we have constructed firm level measures of

1. Total man-years
2. Man-years with at least 12 years of education (High School Diploma)
3. Man-years with at least 15 years of education (Bachelor)
4. Man-years with at least 15 years of education (Bachelor) in engineering or natural science
5. Man-years with at least 17 years of education (Master)

We start out merging the employment and production data to the data used in chapter 6.1 and run variations over the following specification

$$\ln(\text{man years}_{it}^{\text{BSc}}) = \alpha + \gamma \ln(sales_{it}) + \beta \ln(\text{Intramural R \& D}_{it}) + \sum_{t=1}^{t=T} \delta_t D^{year\,t} + \eta_i + \varepsilon_{it} \quad (6.4)$$

Table 6.14. The effect of reported intramural R&D on BSc man-years

	(1)	(2)	(3)
ln(sales)	0,364***	0,363***	0,364***
	(0,052)	(0,052)	(0,052)
ln(Intramural R&D)	0,008***	0,008***	0,003
	(0,003)	(0,003)	(0,006)
ln(Intramural R&D) * below 4 mill			0,006
			(0,007)
ln(Intramural R&D) * SkatteFUNN		0,002	0,003
		(0,003)	(0,004)
ln(Intramural R&D) * SkatteFUNN * below 4 mill			-0,001
			(0,005)
Adj.R-sq (within)	0,21	0,21	0,21
No. of obs.	5787	5787	5787

The dependent variable is ln(man-years with at least three years of higher education). All specifications include firm fixed effects. SkatteFUNN is a dummy variable for receiving the R&D tax credit. "below 4 mill" is a dummy variable for on average to invest less than 4 mill NOK in real R&D prior to the introduction of SkatteFUNN in 2002.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Table 6.15. The effect of reported R&D man years on man-years by education

	(1) All	(2) Edu 12	(3) Tech. edu 15	(4) Edu 17
ln(sales)	0,404***	0,396***	0,382***	0,345***
	(0,060)	(0,058)	(0,058)	(0,056)
ln(Intramural R&D)	0,003	0,002	0,007	0,012*
	(0,008)	(0,007)	(0,008)	(0,007)
ln(Intramural R&D) * below 4 mill	0,000	0,002	0,002	-0,005
	(0,009)	(0,008)	(0,009)	(0,008)
ln(Intramural R&D) * SkatteFUNN	0,005	0,003	0,005	0,008
	(0,004)	(0,004)	(0,005)	(0,005)
ln(Intramural R&D) * SkatteFUNN * below 4 mill	-0,004	-0,003	-0,002	-0,009
	(0,005)	(0,005)	(0,006)	(0,006)
Adj.R-sq (within)	0,27	0,28	0,20	0,15
No. of obs.	5929	5923	5266	5344

All specifications include firm fixed effects. SkatteFUNN is a dummy variable for receiving the R&D tax credit. "below 4 mill" is a dummy variable for on average to invest less than 4 mill NOK in real R&D prior to the introduction of SkatteFUNN in 2002.

* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

Note that we use man years with at least three years of higher education (equivalent to a BSc degree) as most of the man years spend on R&D fall into this category. We check the robustness with respect to this choice in table 6.15.

Table 6.16. The effect of reported R&D on man-years, by education

	(1) All	(2) Edu 12	(3) Edu 15	(4) Edu 17	(4) Tech. edu 15
ln(sales)	0.2467***	0.2271***	0.2183***	0.1680***	0.1775***
	(0.0065)	(0.0066)	(0.0074)	(0.0087)	(0.0078)
ln (Intramural R&D)	0.0177***	0.0194***	0.0173***	0.0105***	0.0118***
	(0.0025)	(0.0025)	(0.0027)	(0.0033)	(0.0029)
ln(Intramural R&D)	-0.0001	-0.0004	-0.0025	-0.0051	0.0015
* Post SkatteFUNN year	(0.0037)	(0.0037)	(0.0039)	(0.0041)	(0.0037)
ln (Intramural R&D)	0.0041	0.0043	0.0061	0.0044	0.0054
* Post SkatteFUNN year	(0.0041)	(0.0041)	(0.0044)	(0.0048)	(0.0042)
* below 4 mill					
ln(Intramural R&D)	0.0063	0.0074*	0.0098**	0.0060	0.0082**
* SkatteFUNN	(0.0040)	(0.0040)	(0.0042)	(0.0044)	(0.0040)
ln (Intramural R&D)	-0.0026	-0.0021	-0.0043	-0.0035	-0.0054
* SkatteFUNN*below 4 mill	(0.0044)	(0.0044)	(0.0047)	(0.0051)	(0.0045)
Constant	0.0268	-0.1609**	-0.6690***	-0.5997***	-0.6050***
	(0.0618)	(0.0628)	(0.0715)	(0.0858)	(0.0779)
Observations	11755	11576	10538	8378	8363
Number of firms	2994	2961	2751	2347	2231
R-squared	0.18	0.16	0.14	0.07	0.11

All specifications include firm fixed effects. SkatteFUNN is a dummy variable for receiving the R&D tax credit. "below 4 mill" is a dummy variable for on average to invest less than 4 mill NOK in real R&D prior to the introduction of SkatteFUNN in 2002.
* Significant at the 10 percent level ** Significant at the 5 percent level *** Significant at the 1 percent level.

Our methodology depends critically on the ability of our data to produce a significant coefficient on β in (6.4). Table 6.14, column (1), shows that we pass this test. Intramural R&D as reported in the R&D surveys does increase the use of BSc-educated labour for a given production level as reported in administrative registers.

The next question we ask is whether this relationship is weaker for firms receiving an R&D tax credit than for other firms. Recall from table 6.2, column (3) and (4) that participation in the tax credit scheme did increase reported R&D man-years. If the effect of reported R&D man-years on labour input is smaller for SkatteFUNN firms, it would suggest that some of the reported increase in R&D represents a shift in reporting behaviour rather than increased R&D efforts.

From column (2) we see that this is not the case. On the contrary, the estimated effect for SkatteFUNN firms is slightly larger than for non-participating firms and for firms prior to the introduction of the scheme. This is somewhat surprising. One interpretation is that SkatteFUNN has caused a more conservative definition of R&D man-years, e.g. by excluding R&D support personnel from the figures13. Another interpretation is that SkatteFUNN has increased the awareness of R&D as a separate activity in the firm and thereby increased the data quality in the R&D surveys. In the reported specification, the effect is not significant however, hence one should not put to much emphasis on the finding.

Only firms that receive subsidies on the margin have an incentive to exaggerate their R&D activities. In column (3) we interact R&D man-years with a dummy for being below the 4 million cap. We find that firms below the cap have a slightly lower coefficient, but the effect is far from significant. The results in table 6.14, therefore, suggest that SkatteFUNN has real effects on the R&D man-years.

Next, we investigate the robustness of this finding by changing our left hand side labour measure. The results are reported in table 6.15. We see that the results are in line with the effects found in table 6.14, column (3).

Results based on R&D from the SkatteFUNN database

Here, we report the results from an analysis similar to the analysis above, but we extend the sample by using the R&D information reported by the firms in the SkatteFUNN application. In this way we can get a sample that is far more representative, cf. chapter 6.5. The specification is similar to the one used above, but we use intramural R&D from the SkatteFUNN application and tax authorities as our measure of R&D. The results are qualitatively in line with those reported above: Increased R&D activities give higher employment relative to sales in the same year. This also applies to SkatteFUNN firms, both above and below the cap.

6.7. Heterogeneity in the degree of additionality

We saw in section 6.5 that the degree of additionality for firms below the 4 million cap appears to vary between firms according to the level of their prior R&D-investments. Firms that had low levels of R&D seem to have responded most strongly to the R&D tax incentives.14 Obviously, the degree of additionality may also vary systematically between firms that differ along other dimensions. In this section, we investigate whether the degree of additionality varies by firm size, location, industry and skill intensity.

[13] R&D support personnel are supposed to be included in the R&D surveys, but not in the SkatteFUNN applications. It is, however, plausible that some firms will use the figures from their SkatteFUNN applications when answering the R&D survey.

[14] Recall, however, that additionality is measured by growth in R&D investments, hence for firms with a low pre SkatteFUNN level of R&D it does not take a very large R&D investment do produce a high growth rate, while the scope for negative growth is limited.

Table 6.17. Short term additionality by size and location

	(1) Small	(2) Medium	(3) Large	(4) Rural	(5) Urban
ln(sales)	0,412	0,522***	0,268**	0,505***	0,297**
	(0,280)	(0,177)	(0,136)	(0,189)	(0,126)
ln(direct subsidies)	0,331***	0,365***	0,377***	0,433***	0,338***
	(0,050)	(0,039)	(0,029)	(0,037)	(0,026)
Post SkatteFUNN year	-0,798	-0,506	-0,871***	0,115	-0,939***
	(0,647)	(0,593)	(0,244)	(0,391)	(0,242)
Post SkatteFUNN year * below 4 mill	-0,715	-0,265	0,896***	-0,369	0,478
	(0,713)	(0,639)	(0,302)	(0,453)	(0,292)
SkatteFUNN	1,136*	1,169**	1,342***	0,706*	1,340***
	(0,663)	(0,521)	(0,254)	(0,393)	(0,233)
SkatteFUNN * below 4 mill	1,954**	1,799***	1,333***	2,008***	1,363***
	(0,758)	(0,581)	(0,333)	(0,477)	(0,294)
Constant term	1,192	-0,912	1,342	-1,547	1,546
	(2,670)	(1,887)	(1,714)	(2,107)	(1,465)
Adj R-sq (within)	0,168	0,136	0,108	0,168	0,100
No. of obs.	1463	2340	4430	2240	5993
No. of SkatteFUNN firms	260	435	457	358	794
No. of SkatteFUNN firms below 4 mill	207	320	292	291	528
Sample means:					
Employees	16	50	269	101	182
R&D man-years	2.3	3.0	3.6	2.1	3.6
R&D intensity	0.17	0.07	0.01	0.04	0.06

The dependent variable is ln(intramural R&D). All specifications include firm fixed.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Table 6.18. Short term additionality by industry

	(1) Lowtech	(2) Hightech	(3) Manufacturing	(4) Services	(5) Other
ln(sales)	0,270**	0,542**	0,461***	0,406**	-0,092
	(0,124)	(0,250)	(0,178)	(0,191)	(0,313)
ln(direct subsidies)	0,446***	0,209***	0,351***	0,377***	0,437***
	(0,028)	(0,028)	(0,026)	(0,044)	(0,084)
Post SkatteFUNN year	-0,734***	-0,904**	-0,637**	-0,967**	-0,986*
	(0,255)	(0,393)	(0,271)	(0,423)	(0,560)
Post SkatteFUNN year * below 4 mill	0,341	0,585	0,526*	-0,206	0,341
	(0,295)	(0,514)	(0,317)	(0,513)	(0,668)
SkatteFUNN	1,256***	1,239***	1,164***	1,392***	1,615***
	(0,287)	(0,350)	(0,277)	(0,386)	(0,581)
SkatteFUNN * below 4 mill	1,624***	1,019**	1,436***	1,396***	0,792
	(0,339)	(0,463)	(0,327)	(0,501)	(0,829)
Constant term	1,085	0,111	-0,594	0,576	5,251
	(1,457)	(2,740)	(2,066)	(2,118)	(3,882)
Adj R-sq (within)	0,129	0,091	0,128	0,111	0,098
No. of obs.	5900	2333	5236	2251	746
No. of SkatteFUNN firms	655	497	784	307	61
No. of SkatteFUNN firms below 4 mill	508	311	601	182	36
Sample means:					
Employees	189	88	145	156	283
R&D man-years	2.2	5.7	3.1	3.9	1.7
R&D intensity	0.03	0.12	0.03	0.12	0.04

The dependent variable is ln(intramural R&D). All specifications include firm fixed.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Our point of departure is the sample and specification used in table 6.2, column (2). For simplicity, we have exchanged the set of year dummies with a single dummy distinguishing between pre and post SkatteFUNN years.

In table 6.17, column (1)-(3) we split the sample according to firm size. Column (1) and (2) include small and medium sized firms. We use the SMB definition laid out in the SkatteFUNN 2002 rules. According to these rules a firm is defined as an SMB if at least two out of the following three criteria are fulfilled: (i) Less than 100 employees (i) Less than 80 million NOK in sales (iii) Less than 40 million NOK in total assets. Since our regression model includes fixed effects, we want firms to stay in the same size category in all years. We have therefore deflated all values to 2002 NOK and classified the firms according to their mean employment, sales and assets. Within the SMB group small firms are defined as firms with mean employment less than 20. The result for this group is reported in column (1). We see from the table that the degree of additionality varies systematically by firm size. Small firms have the highest degree of additionality. From the bottom of table 6.17 we see that small firms have a somewhat lower level of R&D investments than large firms, but the difference are not large

compared to the difference in number of employees. It is likely, but not entirely obvious, that the difference between small and large firms in table 6.17 are driven by the level effects discussed above in relation with section 6.5. In any case, our finding in table 6.17 fits well with our descriptive results in section 5.4 showing that the actual subsidy share – and thereby the strength of the incentive – falls with the firm number of employees.

In table 6.17, column (4) and (5), we split the sample according to location. Rural firms are defined as firms situated in municipalities that have had arrangements for general labour and investments subsidies. We see that the additionality is larger for rural firms. Looking at the firm characteristics at the bottom of the table, however, this is most likely driven by rural firms being both smaller and less R&D intensive.

In table 6.18 we explore whether the degree of additionality vary between industries. We make two broad categorizations. In column (1) and (2) we distinguish between "lowtech" and "high-tech" industries. We classify the following industries as high tech: Chemicals, machinery and equipment, computers, electronics, scientific instruments, computer services and R&D services.[15] The classification is inspired by OECD and expanded by looking at average industry R&D intensity in the sample. We find that the degree of additionality is highest for low-tech firms. Note that average number of employees in this category is more than twice the number of employees for high-tech firms. Average R&D man-years is however far lower, and this is probably the main driving factor.

Table 6.18, column (3)-(5) split the sample in manufacturing firms, service firms and firms in other industries. We see that manufacturing firms and service firms are very similar with respect to additionality, while the estimated additionality in other firms is lower and non-significant. The latter results should probably not be emphasized as the sample size is small with only 61 SkatteFUNN firms included.

The final firm characteristic we explore is skill intensity defined as the share of workers in each firm with higher education. We use the average over all years a firm is observed. We classify firms with a share below 50 % as having a low skill intensity (relative to other SkatteFUNN firms), firms with a share between 50 % and 75 % as having a medium skill intensity and firms with a share above 75 % as having a high skill intensity. We see that the degree of additionality is highest for firms with low skill intensity, but again, the pattern follows the average level of R&D man-years.

[15] The names used are abbreviated. The exact NACE codes included are: 24, 29, 30, 31, 32, 33, 72 and 73.

6.8. Can the assessment of additionality by firms and bureaucrats be trusted?

As pointed out in our descriptive analysis, the SkatteFUNN data include the firms own assessment of project additionality as well as the assessment made by Innovation Norway. It is of great interest to see whether these assessments correspond with our econometric analysis. In order to do so we use the same sample and basic specification as in the heterogeneity analysis in section 6.7, but now we want to explore whether the degree of additionality vary according to the firms' self assessment and the assessment by Innovation Norway. This is done in table 6.20, column (1) and (2) respecttively. All projects contain the assessment of Innovation Norway, while there are a lot of missing data with respect to firms' self assessment. Firms are asked about their self assessment both in the application and in the end report. To reduce the problem of missing data, we have combined these sources.[16]

The dummy variables for "Post SkatteFUNN year* below 4 million", "SkatteFUNN" and "SkatteFUNN*below 4 million" are exchanged with a set of variables distinguishing between projects with low assessed additionality, medium assessed additionality and high assessed additionality. In addition we control for whether the firm in the end received a tax credit or not. Starting out with the assessment of Innovation Norway in column (2), we find that estimated additionality increases with the score they give on additionality.[17] It is hard to evaluate whether the magnitude of the effects are satisfactorily, but the pattern clearly give some credibility both to the way the SkatteFUNN applications are assessed and to the ability of our regressions to measure additionality.

Results regarding the firms' self assessment are reported in column (1). The way firms are asked about additionality differs from how Innovation Norway makes their assessment, and it is slightly more difficult to classify the answers in low, medium and high. The reason for this is that there is a time dimension in the answers. Projects may be postponed, and hence there is a possible issue with short term vs long term additionality. Our estimates do not suggest any difference between low and medium additionality, but projects that the firms claim to have high additionality do indeed seem to be associated with higher growth in R&D investments. Our difficulty with the classification

[16] When both scores are available we use the mean of the two scores, otherwise we use the one that is not missing.

[17] Each project is given a score from 1 to 7. If a firm has several projects, we aggregate these using their total budget as weights. We group score 1 and 2 into the category low additionality. Score 3 and 4 constitute in our analysis medium additionality and score 5, 6 and 7 are classified as high additionality. Relatively few projects have 6 or 7, and in more detailed analyses we cannot estimate higher additionality for projects with these scores than for projects with score 5.

regards where to draw the line between full and medium additionality. The estimation result is therefore somewhat surprising. What the numbers tell us is that there is no difference between firms that plainly state that a subsidy would not affect them (low additionality – score 1) and those who state that the project would have been scaled down or postponed without the subsidy (medium additionality –score 2 and 3). Those who state that the project would have been put off or "put on hole" (score 4 and 5), however, seem to have higher growth in their R&D investments than the others. Hence, there seems to be some truth in self assessments. Given that Hervik et al (2006) for many years have evaluated the subsidy programs of the Research Council and Innovation Norway based on firms' self assessment, another result would have been rather disturbing.

Finally, we may note that firms that applied, but in the end did not receive a tax credit, have lower R&D growth than others. This is to be expected.

Table 6.19. Short term additionality by skill intensity

	(1) Low	(2) Medium	(3) High
ln(sales)	0,551***	0,383**	0,131
	(0,209)	(0,192)	(0,144)
ln(direct subsidies)	0,439***	0,349***	0,314***
	(0,041)	(0,036)	(0,036)
Post SkatteFUNN year	-0,594	-0,844***	-0,851**
	(0,543)	(0,317)	(0,348)
Post SkatteFUNN year * below 4 mill	0,458	0,366	0,106
	(0,582)	(0,388)	(0,460)
SkatteFUNN	0,660	1,447***	1,391***
	(0,483)	(0,358)	(0,300)
SkatteFUNN * below 4 mill	1,979***	1,506***	1,132***
	(0,535)	(0,431)	(0,433)
Constant term	-2,247	0,157	4,082**
	(2,443)	(2,267)	(1,598)
Adj R-sq (within)	0,133	0,120	0,096
No. of obs.	3003	2760	2093
No. of SkatteFUNN firms	357	376	418
No. of SkatteFUNN firms below 4 mill	317	271	230
Sample means:			
Employees	163	209	105
R&D man-years	2.1	3.1	4.8
R&D intensity	0.02	0.03	0.13

The dependent variable is ln(intramural R&D). All specifications include firm fixed.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Table 6.20. R&D growth and assessment of additionality by firms and bureaucrats

	(1) Assessment by the firm	(2) Assessment by Innovation Norway
ln(sales)	0,318***	0,323***
	(0,110)	(0,109)
ln(direct subsidies)	0,386***	0,384***
	(0,022)	(0,022)
Post SkatteFUNN year	-0,592***	-0,597***
	(0,118)	(0,117)
Applicant with low additionality	2,492***	2,122***
	(0,236)	(0,203)
Applicant with medium additionality	2,377***	2,462***
	(0,151)	(0,148)
Applicant with high additionality	2,782***	2,650***
	(0,235)	(0,216)
Tax credit redjected	-1,134***	-1,201***
	(0,262)	(0,228)
Constant term	1,052	1,007
	(1,265)	(1,257)
Adj R-sq (within)	0,110	0,113
No. of obs.	8036	8182

The dependent variable is ln(intramural R&D). All specifications include firm fixed.effects.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Table 6.21. Short term additionality for R&D bought from universities and research institutes

Dependent variable	(1) Internal R&D	(2) Total R&D	(3) Total R&D	(4) R&D bought from research institutions	(5) Other cooperative R&D
Cap	4 million	8 million	8 million	8 million	8 million
ln(sales)	0,389***	0,464***	0,464***	0,249***	0,412***
	(0,120)	(0,116)	(0,116)	(0,081)	(0,089)
Dummy for 1995	0,480**	0,595***	0,596***	0,105	0,130
	(0,197)	(0,202)	(0,203)	(0,135)	(0,172)
Dummy for 1997	0,387*	0,444*	0,445*	0,321**	-0,510**
	(0,228)	(0,234)	(0,234)	(0,157)	(0,202)
Dummy for 1999	-0,214	-0,177	-0,177	0,048	-0,414**
	(0,231)	(0,237)	(0,237)	(0,152)	(0,199)
Dummy for 2001	0,878***	0,894***	0,896***	-0,065	-0,257
	(0,230)	(0,235)	(0,235)	(0,154)	(0,192)
Dummy for 2002	-0,316	-0,522*	-0,521*	-0,787**	-1,050***
	(0,292)	(0,308)	(0,308)	(0,314)	(0,341)
Dummy for 2003	-0,656**	-0,812**	-0,811**	-0,783**	-1,215***
	(0,316)	(0,325)	(0,325)	(0,314)	(0,351)
Dummy for 2004	-0,905***	-1,018***	-1,018***	-0,885***	-1,172***
	(0,314)	(0,322)	(0,322)	(0,318)	(0,349)
Dummy for 2005	-1,051***	-1,162***	-1,163***	-1,012***	-1,522***
	(0,322)	(0,330)	(0,330)	(0,321)	(0,347)
Post SkatteFUNN year * below cap	0,477*	0,647**	0,647**	0,567**	0,615**
	(0,261)	(0,281)	(0,281)	(0,283)	(0,303)
SkatteFUNN	1,283***	1,300***	1,301***	0,433	0,541
	(0,212)	(0,251)	(0,251)	(0,315)	(0,409)
SkatteFUNN * below cap	1,550***	1,237***	1,297***	0,170	0,413
	(0,251)	(0,281)	(0,286)	(0,336)	(0,437)
SkatteFUNN * below cap * research institute			-0,220		
			(0,181)		
Constant	0,375	-0,207	-0,213	-1,572*	-2,287**
	(1,350)	(1,314)	(1,313)	(0,919)	(1,013)
Adj R-sq (within)	0,077	0,071	0,071	0,020	0,021
No. of obs.	8390	8390	8390	8363	8344

UR is a dummy for reporting R&D bought from universities and research institutes. All specifications include firm fixed.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

6.9. More on the incentive to do cooperative R&D with universities and research institutes

In section 6.4 we analyzed the probability to start or continue extramural R&D done in cooperation with universities, colleges and research institutes. We found only weak evidence that the probability to start such R&D had increased after the introduction of SkatteFUNN, and no evidence to suggest that the probability to *continue* such R&D had increased.

In this section we analyze this question in some more detail. The results are reported in table 6.21. Our point of departure is the specification in table 6.2, column (2). However, we cannot control for direct grants used to finance cooperative R&D because such data is not available for all years. We therefore start out estimating the effect of SkatteFUNN on intramural R&D without controlling for direct grants. We see that leaving out this control has little effect on the coefficients of interest. The estimated additionality becomes slightly higher, 1.550 rather than 1.331 in table 6.2 column (2). Next, we want to include extramural R&D in our analysis. The relevant cap is then 8 million, as all firms that would do less than 8 million in total R&D in absence of the SkatteFUNN scheme have an incentive to increase their R&D by buying R&D services from research institutions. We see that the estimated additionality for total R&D is smaller than for intramural R&D suggesting that the effect of SkatteFUNN on extramural R&D has not been as large as on intramural R&D. Keep in mind, however, that the estimated effect on intramural R&D is quite large. Moreover, the difference between the two estimates is not statistically significant, and the control group becomes relatively small when the relevant cap is 8 million. There are 1276 firm-year observations in the sample, with average R&D prior to SkatteFUNN above 8 million. 213 of these have received a tax credit.

In column (3) we expand the specification in column (2) by looking at the interaction between being a SkatteFUNN firm below the 8 million cap with actually receiving support for buying R&D from research institutions. We see that the increase in total R&D is not higher for those who use this opportunity to receive an extra tax credit than for those who do not use this opportunity[18].

[18] Interacting the dummy for buying R&D from a research institution with more variables does not change this result.

Table 6.22. Effects of R&D subsidies on firm average annual wage for R&D personnel

	(1) All firms	(2) SMBs	(3) Large firms
Sales per R&D man year/1000	0,024	0,400*	0,023
	(0,017)	(0,233)	(0,017)
Direct subsidies per R&D man year	0,095**	0,168***	0,052
	(0,042)	(0,059)	(0,041)
Tax credit per R&D man year	0,328***	0,528***	0,130
	(0,087)	(0,174)	(0,095)
Dummy for 1995	0,226	0,306	-1,577
	(15,265)	(22,347)	(20,193)
Dummy for 1997	22,813	26,790	21,757
	(17,985)	(29,073)	(22,553)
Dummy for 1999	9,881	28,443	-0,952
	(17,510)	(26,569)	(22,377)
Dummy for 2001	22,922	27,258	20,963
	(17,833)	(27,204)	(22,914)
Dummy for 2002	26,512	22,436	20,339
	(20,367)	(32,785)	(25,182)
Dummy for 2003	29,116	39,754	20,545
	(18,853)	(31,819)	(24,227)
Dummy for 2004	-8,419	-19,432	5,273
	(17,771)	(31,772)	(21,868)
Dummy for 2005	-6,282	-7,103	-0,202
	(18,483)	(30,760)	(23,603)
Constant	530,212***	475,283***	561,148***
	(13,606)	(22,501)	(17,424)
Adj R-sq (within)	0,034	0,108	0,008
No. of obs.	5700	2776	2924

All specifications include firm fixed. Firms that report zero R&D wage costs or zero R&D man-years are excluded from the sample.See section 6.7 for a definition of firm sizes.

Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

In the next two columns we split extramural R&D in R&D bought from research institutions and other cooperative R&D, that is R&D services bought from other firms or research institutions not approved by SkatteFUNN. SkatteFUNN should increase the incentive to buy R&D from approved research institutions, and have no direct effect on the incentive to do other cooperative R&D. There could, however, be a negative indirect effect as firms may choose to substitute away from R&D that is not covered by SkatteFUNN.[19] We see that both effects are positive, but not significant. Moreover, the estimated effect on R&D bought from research institutions is smaller than the effect on other cooperative R&D. Hence, the data do not suggest that SkatteFUNN has had a strong impact on the incentive to do extramural R&D in cooperation with universities, colleges and research institutes. This is somewhat puzzling as for most firms the marginal price on such R&D has been lowered. Partly the negative result may be due to the control group of firms above the 8 million cap being very small. Recall from chapter 4 that only 0.5% of all 11 144 firm year observations with a positive R&D tax credit reached the cap for total R&D while 30 % actually received a tax credit for extramural R&D.

[19] In principle there could also be an indirect positive effect if other cooperative R&D projects are strongly complementary to R&D covered by SkatteFUNN.

6.10. Effects of SkatteFUNN on the wage for R&D personnel

With a limited supply of R&D workers in the short run, one runs the risk that R&D subsidies will increase R&D wages rather than R&D man-years. Using US data, Goolsbee (1998) provides evidence of such an effect, and OECD (2007) in their recent Economic Survey has pointed to this as a main concern when discussing Norwegian R&D policy. Register data, i.e. data with wages for individual workers will be more suitable for analyzing this question than the data used for this evaluation project. However, the data at hand lend themselves easily to a first look. In the R&D surveys firms both report the total wage bill for R&D personnel and the R&D man-years. This allows us to calculate the firm average annual wage for R&D personnel. The calculated mean is 252 000 NOK (2003 values) with a standard deviation of 127 000. This seems somewhat low, but the level is not central to our analysis.

In table 6.22 we regress firm average annual wages for R&D personnel on sales per R&D man year, direct R&D subsidies per R&D man year, the R&D tax credit per R&D man year, year dummies and firm fixed effects. The estimated wage effects of subsidies are rather substantial. If a firm receives 100 000 in direct subsidies per R&D man year, each R&D worker receive about 10 000 as a wage increase. If a firm receives 100 000 in tax credit per R&D man year, each R&D worker receive about 33 000 as a wage increase. From column (2) and (3) we see that the estimated effects are driven by small- and medium-sized firms. For this group, the estimated wage increase is 17 000 per

100 000 in direct subsidies and 53 000 per 100 000 in tax credit. Note, however, that R&D wages in SMBs are also far more responsive to sales than R&D wages in large firms.

These results are suggestive, but before jumping to conclusions we should note that the effects are likely to be severely biased by measurement errors in the R&D man year variable. Since this is used in the denominator both at the left hand side variable and in several of the right hand side variables it introduces a spurious correlation. If e.g. reported R&D man-years are too small, the average annual R&D wage will be too large. Sales, direct subsidies and tax credits per R&D man year will also be too large, and this will cause a positive bias in their coefficients. The much larger effect of the tax credit as compared to direct subsidies is still intriguing, and warrant further research.

Finally, we should mention that some increase in R&D wages as a result of R&D subsidies is to be expected if R&D subsidies is efficient in rising R&D investments. These higher wages will help attract more researchers in the long run, which is necessary if total R&D efforts are to increase. Remember also that we did find a positive effect of the R&D tax credit on R&D man-years in table 6.4. If the supply of R&D workers is very inelastic, however, or if existing R&D workers are able to get hold of a substantial part of the subsidies as a rent, R&D subsidies will be a rather inefficient policy.

6.11. Bang for the buck? How much additional R&D per krone tax receipt forgone?

So far our main focus has been on whether the R&D tax credit scheme has stimulated additional R&D investments. Although our estimated results are mainly driven by firms that did very little R&D prior to SkatteFUNN, and they are sensitive to sample restrictions and model specifications, the evidence we have produced suggest that SkatteFUNN has stimulated additional R&D investments. This is to be expected when the price of R&D is reduced. Establishing this, however, is not enough to conclude that the scheme is successful. The key question is *how much* additional R&D has been induced *per krone spent* on the scheme. This ratio is in some previous studies known as "bang for the buck" or even just BFTB – a somewhat amusing terminology we chose to adopt.[20] Estimating how much additional R&D the scheme has induced is obviously far more challenging than estimating whether the effect is positive or not. Our strategy will be to produce estimates based on different models and assumptions in order to see whether different approaches will produce numbers of similar magnitude. However, we again stress that these different numbers do not represent *independent* estimates of the BFTB, since they rely on different representations of partly the same data, and the same fundamental identification problem applies in all approaches, since it is an inherent characteristic of the scheme itself

Before presenting the actual estimates, let us notice that a project that would not have been undertaken at all without the R&D tax credit will have a BFTB of 1/0.20=5 if an SME and 1/0.18=5.56 if not an SME. A project that would have been undertaken in full without the tax credit will have a BFTB of zero. So, any BFTB less than five implies that there is a "deadweight loss", i.e. that tax support is given to some R&D that would have been undertaken anyway. Typically, a BFTB of 1 or slightly more is considered acceptable. That implies that money spent on the R&D tax credit increase private R&D investments krone by krone. In absence of a cap, and with a 20 % tax credit, a BFTB =1, demands that firms respond to the R&D tax credit by a 25 % increase in their R&D spending.

BFTB based on self-reported additionality

A first estimate for BFTB can be calculated from the ex post self-reported additionality in the SkatteFUNN final project reports, cf. section 5.5. Here, firms are asked what would have happened to the project without support from SkatteFUNN. To each of the alternative answers we attach an "additionality factor", saying how large fraction of the reported R&D that we assume to be a result of the tax credit. These factors are admittedly set somewhat arbitrarily, except for the alternatives "Carried out at the same scale and time horizon" and "Dropped", where the natural additionality factors are zero and one, respectively. We therefore experiment with three different sets of additionality factors.

The additional R&D generated from a SkatteFUNN project is then calculated as the R&D reported to the tax authorities (censored at NOK 10 mill) multiplied by the additionality factor. Summing this over all firms an BFTB is then calculated as the sum of the additional R&D across firms, divided by the total tax credit for the same firms. Using set A of additionality factors yields a BFTB of 2.65, the more "conservative" set B gives 2.12, while set C gives 2.64, showing that how the "do not know" category is treated has only minor implications for the results.

Table 6.23. Assumptions on "additionality factors"

	Additionality factor		
	A	B	C
Carried out at the same scale and time horizon	0	0	0
Carried out at the same scale, but over a longer time horizon	0.25	0.2	0.25
Limited scale	0.5	0.4	0.5
Postponed	0.75	0.6	0.75
Dropped	1	1	1
Do not know	0.5	0	dropped

[20] Our source of inspiration is de Jong and Verhoeven (2007).

BFTB based on data from the R&D survey
Recall equation 6.3, the specification behind table 6.2, column (1):

$$\ln(R\,\&\,D_{it}) = \alpha + \gamma \ln(sales_{it}) + \chi \ln(subsidies_{it}) + \sum_{t=1}^{t=T} \delta_t D^{year\,t} + \sum_{t=0}^{t=T} \varphi_t D^{year\,t} \cdot D^{belowCap} + \theta SF + \beta SF \cdot D^{belowCap} + \eta_i + \varepsilon_{it}$$

Here β gives us the change in log R&D induced by a firm below the cap receiving the R&D tax credit – all else equal. This implies that the expected value of the counter factual R&D investment in absence of a tax credit for a firm below the cap is

$$\ln(R\,\&\,D_{it}^{\text{without tax credit}}) = \ln(R\,\&\,D_{it}^{\text{with tax credit}}) - \beta$$
$$\Leftrightarrow R\,\&\,D_{it}^{\text{without tax credit}} = R\,\&\,D_{it}^{\text{with tax credit}} \Big/ \exp(\beta)$$

Our estimate for β is 1.282. Taking the model at face value, the expected R&D investment in absence of the scheme for firms below the cap participating in the scheme, is then their observed R&D under the scheme divided by exp(β)=3.60. Calculating this counterfactual R&D for all firms in the sample below the cap participating in the scheme and summarizing the difference between this and each firms' observed R&D investment we get NOK 1 729 846 000. Next, summarizing the R&D tax credit received by all firms in the sample, both firms above and below the cap, we get 595 895 000. The ratio of these two numbers, 2.90 gives us an estimate for the "BFTB" for the firms in our sample. Apparently, then, each krone tax receipt forgone has induced 2.90 kroner additional R&D. Recall, however, that the β -estimate is very uncertain, cf. chapter 6.1, and also that the sample used in the main regression is not representative for the true composition of firms participating in the scheme, cf. chapter 4.

BFTB based on data from the SkatteFUNN applications
Table 6.12 suggested that the effect of SkatteFUNN varied substantially between large and small R&D performers, and taking account of this should give us a more reliable BFTB. Furthermore, the estimates in table 6.12 were based on the actual population of SkatteFUNN firms. Obviously, this is also beneficial when estimating BFTB, although the drawbacks related to the SkatteFUNN data discussed in chapter 6.5 should be kept in mind.

Estimating the expected R&D investments in absence of SkatteFUNN (based on the estimates in table 6.12 (column 1) and summarizing the difference between these numbers and the actual R&D investments in the same manner as above, we find that the additional R&D induced by SkatteFUNN amounts to NOK 3 170 250 000 . Total R&D tax credits awarded to the firms in the sample sum to NOK 2 488 312 000, hence we get a BFTB of 1.27. The sample does not include firms that did not do R&D prior to the introduction of SkatteFUNN. Adding R&D done by these firms and making use of their self reported additionality, in absence of an econometric estimate, brings the BFTB to 1.51

BFTB based on estimates from a companion report Hægeland and Møen (2007)
In a companion report "The relationship between the Norwegian R&D tax credit scheme and other innovation policy instruments" (Hægeland and Møen, 2007) we estimate the additionality of the R&D tax credit and other R&D subsidies simultaneously using a linear specification taken from the literature on the additionality of direct R&D grants. In the main speficiation reported in table 5.3, column (1) we find that each krone tax credit induce 2.55 krone additional R&D for firms below the cap. Firms below the cap in the sample receive 357 059 in tax credit while firms above the cap receive 196 558. This gives a BFTB estimate of (2.55* 357 059)/(357 059 + 196 558) = 1.64. The sample is based on observations in the R&D surveys. Assuming that the coefficient is valid for the sample of SkattFUNN firms used in the estimations based on the SkatteFUNN database, we get a BFTB of 1.99.

7. Conclusions

The Norwegian R&D tax credit was introduced with the goal to increase innovation and creation of values in trade and industry, and to improve R&D efforts. The degree of input additionality, i.e. to what extent the scheme induces firms to invest more in R&D than they otherwise would have done, is obviously important when evaluating the overall efficiency of the scheme. Data for aggregate R&D investments in Norway suggest that the scheme has not achieved what the government aimed for. However, the scheme is not designed for large firms driving the development of aggregate R&D investments, and it is possible that R&D investments would have been still lower in absence of the scheme. Hence, a counterfactual analysis using firm level data is called for.

Using firm level data, we find that firms receiving the R&D tax credit have stronger growth in their R&D investments than firms not receiving an R&D tax credit. Obviously, this may be driven by selection. Since the scheme is universal, it is very challenging to construct a valid control group. The most promising identification strategy is to compare applicant firms that previously have invested less than the cap with applicant firms that previously have invested more than this cap. R&D investments are fairly stable, and the latter group should not have a strong incentive to increase their R&D investments *because of* the R&D tax credit. An increase in their R&D investments will not affect their total subsidy. Only firms that would invest less than the cap in absence of the tax credit, have their marginal R&D cost affected.

Our main findings may be summarized as follows:

- Firms that previously invested less than the cap increase their R&D more than firms that previously invested above the cap.
- Firms that previously did not invest in R&D are more likely to start investing in R&D after SkatteFUNN was introduced.
- The effect of SkatteFUNN appears to be real in terms of increasing R&D man-years and increased used of skilled labour given output level.
- The estimated positive additionality is mainly driven by firms that did little R&D prior to SkatteFUNN.
- The additionality effect is strongest in small, low-tech and relatively low-skilled firms, i.e. firms that traditionally did little R&D.
- SkatteFUNN has not had a strong impact on R&D in cooperation with universities, colleges and research institutes.
- Theory suggests that the additionality should be higher in the longer run. Our results do not give a clear answer to whether this is the case.
- Self-reported additionality in applications and final reports, and additionality assessments from application processors are qualitatively consistent with the econometric results

In sum, we interpret the empirical evidence to be consistent with the Norwegian R&D tax credit being effective in stimulating private R&D investments.

The results are broadly consistent across the data sources and the model specifications we use. However, one should bear in mind that the identification strategy is not fully "waterproof", and that a causal interpretation of our findings relies itself on assumptions that are not innocuous. Moreover, the large estimated additionality effect is mainly driven by firms that did very little R&D prior to SkatteFUNN. The estimates have considerable uncertainty, and the magnitude of the estimates is also sensitive to non-trivial choices made in sample construction and model specification. One should therefore exert caution in putting too much weight on quantitative results from this analysis. Having said that, our estimates of how much R&D that is generated per krone in forgone taxes, span from 1.3 to 2.9. There is considerable uncertainty associated with these estimates, and they are not independent, since they rest on variations of the same identification strategy. The uncertainty is therefore associated to the whole interval, and does not vanish if one chooses some "midpoint" estimate. However, if we were to give a single best guess, we would say that one krone in support through

SkatteFUNN generates around two kroner in private R&D.

We may sum up by paraphrasing Zvi Griliches (1986): The evidence presented here should not be interpreted as "proving" that SkatteFUNN causes firms to increase their R&D investments, but rather as representing some prima facie evidence in support of such an interpretation.

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