Ådne Cappelen, Arvid Raknerud og Marina Rybalka

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Foreløpig rapport om resultataddisjonalitet

The effect of R&D tax credits on firm perfomance

Preliminary version

Statistisk sentralbyrå • Statistics Norway
Oslo–Kongsvinger

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Sammendrag

Ådne Cappelen, Arvid Raknerud og Marina Rybalka

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Foreløpig rapport om resultataddisjonalitet

Rapporter 2007/22 • Statistisk sentralbyrå 2007

SkatteFUNN ble opprettet i 2002 som et tiltak for å øke norsk næringslivs forsknings- og utviklingsinnsats. Statistisk sentralbyrå har siden 2004 evaluert ordningen og sluttrapport fra evalueringen skal foreligge innen utgangen av 2007. I denne rapporten presenterer vi foreløpige resultater fra et delprosjekt i evalueringen som omhandler virkningen av ordningen på foretakenes resultater, såkalt resultataddisjonalitet, og fokuserer på effekten SkatteFUNN kan ha på foretakenes produktivitet og lønnsomhet. I en økonomisk analyse av ordningen er det viktig å framskaffe noenlunde sikre estimater på hva effektene av ordningen er. Det finnes flere tilnærmingsmåter til studier av effekter av FoU på økonomien i den økonomiske faglitteraturen. Vi dokumenterer resultater fra flere typer økonometriske modeller i denne rapporten, dels for å belyse ulike problemstillinger og dels for å oppnå mer robuste konklusjoner. I det følgende kommer en oppsummering av metoder og hovedresultater. De detaljerte analysene er presentert i vedlegget (på engelsk). Våre foreløpige resultater kan tyde på at SkatteFUNN bidrar til økt produktivitet i næringslivet, men at avkastningen av selve SkatteFUNN subsidien er moderat.

Prosjektstøtte: Norges forskningsråd.

Abstract

Ådne Cappelen, Arvid Raknerud and Marina Rybalka

The effect of R&D tax credits on firm perfomance

Preliminary version

Reports 2007/22 • Statistics Norway 2007

Norwegian business spending on R&D is rather low by OECD standards. In 2002 the Norwegian government introduced a tax based incentive, SkatteFUNN, in order to stimulate business R&D. We analyse the effects of SkatteFUNN on firm performance using Norwegian micro data. Our estimates of reduced form productivity equations are generally in line with results in the literature. R&D spending increases productivity at the firm level even after controlling for a number of possible effects relating to industries, common shocks etc. The effect of the tax credit is generally not significant in these models. The interpretation is that to the extent that the tax credit increases R&D, its effect is captured by our R&D variables just like R&D spending in general. Using a more structural model for firm performance, where the productivity process is considered as an unobservable process that depends on the tax credit, we find that the tax credit has a positive but not very significant effect on productivity growth. Our preliminary results from this model indicate that the tax credit leads to an increase in productivity, but that the rate of return to the tax credit, considered as a marginal investment in the firms, is modest.

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Innhold

1. Generelt om forskningens betydning for produktivitet

Det er en vanlig oppfatning at forskning og ny teknologi er blant de viktigste drivkreftene for økonomisk utvikling. Det aller meste av den forskning og teknologiutvikling som er nyttig for Norge, utføres og utvikles i utlandet. Årsaken til dette er ikke at Norge investerer lite i egen forskning, men skyldes at Norge er et lite, åpent land i verden med en spesialisert næringsstruktur. Kunnskapsspredning på tvers av landegrenser, kan friste små land til å rendyrke rollen som "gratispassasjer", dvs. å la andre land bære kostnadene ved utvikling av ny kunnskap og nye produkter. Profitabel utnyttelse av nye ideer krever imidlertid rask tilgang til ideene og god evne til å implementere resultatene av andres innsats. Et nøkkelspørsmål for Norge, er derfor hvordan vi skaffer oss tilgang til den internasjonale kunnskapsfronten og sikrer effektiv overføring av teknologi til innenlands bruk og videreutvikling. Her spiller både utdanningsnivået i befolkningen og egen forskningsinnsats viktige roller.

Opptrappingsplanen for norsk forskning tok opprinnelig sikte på å bringe de norske forskningsinvesteringene, målt som andel av BNP, opp på OECD-gjennomsnittet i løpet av 2005. Forskningsmeldingen - St.meld.nr.20 (2004-2005) "Vilje til forskning" - stiller opp et mål om at forskningsinnsatsen i Norge skal økes til 3 prosent av BNP innen 2010. Av dette skal 2 prosentpoeng, eller to tredjedeler, foregå i næringslivet. Siden FoU i næringslivet i dag utgjør under 1 prosent av BNP, må det altså skje en betydelig økning i næringslivets forskningsinnsats framover, selv om en skulle forlenge tidshorisonten med noen år.

Forskningspolitikk består av en rekke komponenter. For det første har vi forskningsinnsatsen som finansieres gjennom bevilgninger over statsbudsjettet til statlige forskningsinstitutter. Dernest har vi bevilgningene via NFR til instituttsektoren mer generelt. For det tredje har vi indirekte skatteinsentiver til forskning både via utformingen av skattesystemet generelt og SkatteFUNN spesielt. For det fjerde spiller det offentlige en viktig rolle for utdanning av forskningspersonell. Endelig spiller statlig politikk, og spesielt næringspolitikken, en indirekte rolle for næringslivets FoU-innsats. I dette notatet presenterer vi resultater fra ulike økonometriske undersøkelser som forsøker å svare på om SkatteFUNN påvirker foretakenes produktivitet, noe som er ett hovedmål med å øke næringslivets FoU-innsats.

Å skille mellom bedriftsøkonomisk, eller mer generelt, privatøkonomisk avkastning av forskning og samfunnsøkonomisk avkastning, er viktig. Med privatøkonomisk avkastning av et prosjekt mener vi avkastningen som tilfaller de som gjennomfører prosjektet. FoU-investeringer vil imidlertid også kunne ha eksterne effekter, dvs. at de påvirker resultatet i andre foretak enn de som foretar investeringene. Med samfunnsøkonomisk avkastning mener vi summen av gevinster og tap som prosjektet påfører alle aktører i økonomien. Den positive samfunnsøkonomiske avkastningen kan også tilfalle foretak utenfor landegrensene, noe vi må anta særlig vil være tilfellet for små land.

Det er flere grunner til at andre enn de som finansierer et forskningsprosjekt kan tjene eller tape på prosjektet. Det er ofte vanskelig å forhindre at andre vederlagsfritt kan imitere forskningsresultater.[1] Nye produkter kan være komplementære med eksisterende produkter og dermed øke nytteverdien av disse, slik forholdet er for eksempel mellom ny programvare og datamaskiner.[2] Dagens forskningsresultater legger grunnlaget for morgendagens forskning og bidrar dermed til avkastningen på framtidens forskningsprosjekter.[3] Imperfeksjoner i kapitalmarkedet kan medføre at de som finansierer forskning må bære så stor risiko at prosjekter som ville vært samfunnsøkonomisk lønnsomme ikke blir realiserte.[4]

Imidlertid finnes det også effekter som trekker i motsatt retning. Noen ganger vil flere foretak investere i like forskningsprosjekter i håp om å være først ute med å patentere et nytt produkt, noe som ville kunne inne-

[1] Denne ideen går tilbake til Arrow (1962). Se Jaffe (1986) for en viktig empirisk studie.

[2] Denne ideen er formalisert i Breshnahan og Trajtenberg (1995).

[3] Se f.eks. Romers vekstmodell fra 1990.

[4] Se Hall (2002) for en litteraturoversikt.

bære samfunnsøkonomisk sløsing.[5] Dessuten kan det være privatøkonomisk lønnsomt å foreta store FoU-investeringer for å gjøre marginale innovasjoner, hvis man dermed kan utkonkurrere eksisterende og svært profitable produkter.[6] Hvorvidt disse negative effektene er større enn de positive, er et empirisk spørsmål. Offentlige tilskudd til ordninger som primært bidrar til marginale produktforbedringer, behøver ikke ha høy samfunnsøkonomisk avkastning. Den samlede privatøkonomiske avkastningen vil kunne være liten, siden gevinsten for innovatøren skjer på bekostning av andre produsenter.

Det foreligger en omfattende internasjonal litteratur som forsøker å beregne avkastningen på forskningsinvesteringer. Det er imidlertid store metodiske problemer knyttet til slike beregninger, og resultatene spriker betydelig. På tvers av alle metoder og fagmiljøer er det likevel konsensus om at avkastningen på forskning er høy, og at den samfunnsøkonomiske avkastningen er vesentlig høyere enn den privatøkonomiske. Griliches (1995) oppsummerer ti empiriske studier fra perioden 1962-1993 og rapporterer estimater for den privatøkonomiske marginale bruttoavkastningen i området 9-56 prosent med en median på 25 prosent.[7] Estimatene for den samfunnsøkonomiske avkastningen er i området 10-160 prosent med en median på 73. Ni studier av offentlige forskningsprosjekter gir estimater for avkastningen i området 20-67 prosent med en median på 38. Klette og Johansen (1998) analyserer norske data og estimerer den privatøkonomiske avkastningen til 45 prosent. Dette er på linje med tall fra andre land. Deres foretrukne estimat for den private marginale nettoavkastningen er 9 prosent. Klette og Johansen analyserte industridata for årene 1980-1992. Hervik og Waagø (1997) finner i et utvalg private prosjekter gjennomført med offentlig støtte, en bedriftsøkonomisk gjennomsnittsavkastning i størrelsesorden 5-10 prosent. Gitt risikoen i slike prosjekter er dette ikke spesielt høyt. Den samfunnsøkonomiske avkastningen kan være høyere, men behøver ikke være det.

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[5] Se f.eks. Irwin og Klenow (1996) som finner at forskningssamarbeid gjennom konsortiet SEMATEC, opprettet i 1987, reduserte duplikativ FoU i den amerikanske halvlederindustrien med 300 millioner dollar per år.

[6] Lichtenberg (1998) påviser eksempelvis at introduksjon av nye medisiner reduserer salget av nære substitutter.

[7] Bruttoavkastning er realavkastning pluss depresiering. Den privatøkonomiske depresieringsraten antas vanligvis å ligge i størrelsesorden 15-20 prosent, mens den samfunnsøkonomiske antas å være vesentlig lavere.

2. Nærmere om metodevalg i vår studie

Vi presenterer i dette notatet resultater fra økonometriske studier på norske data av bedriftsøkonomiske effekter av FoU-innsats generelt og SkatteFUNN spesielt. Generelt samsvarer våre resultater godt med tidligere norske og til dels internasjonale studier som er referert ovenfor. Vi studerer effekter på produktivitet og avkastning. En må her skille mellom avkastningen på prosjekter (delvis) finansiert gjennom SkatteFUNN og avkastningen av selve subsidien. Denne rapporten belyser begge problemstillingene. Derimot studerer vi ikke effekter på innovasjonsaktiviteter, slik som nye produksjonsprosesser eller andelen nye produkter i bedriftenes produktspekter. Vi ser heller ikke på eksterne effekter, slik som spill-over-effekter mellom FoU-innsats i ”nærliggende” foretak.

Vi bruker ulike metodiske tilnærminger i analysen, dels for å oppnå mer robuste konklusjoner og dels for å belyse ulike problemstillinger. De to første tilnærmingene, som er svært vanlige i litteraturen, er basert på at foretakets produktivitet (total faktorproduktivitet) avhenger av dets FoU-innsats (og andre mer eller mindre uobserverte faktorer). FoU-innsatsen betraktes som en investering som akkumuleres til FoU-kapital. Det finnes ingen allment akseptert metode for hvordan man i praksis skal foreta en slik akkumulering av FoU-investeringer. I vår første empiriske tilnærming legger vi til grunn at FoU-kapital depresieres raskt. Denne kapitalen tenker vi oss så inngår som en komponent i foretakets totale faktorproduktivitet. Vår andre empiriske tilnærming har det motsatte utgangspunkt; at FoU-kapital depresieres svært langsomt. Det betyr at produksjonsprosessen har ”lang hukommelse” slik at verdien av FoU-investeringer langt tilbake i tid fortsatt er aktuelle i dag. La oss illustrere de to tilnærmingene med litt enkel matematikk.

La *Y* stå for bedriftens produksjon i faste priser, dvs. et volummål for produksjon, *L* arbeidskraft målt i antall timeverk, *K* realkapital i faste priser (dvs. maskiner og bygninger) og *RK* beholdningen av FoU-kapital (målt i faste priser). Vi tenker oss at sammenhengen mellom produksjon og faktorinnsats kan uttrykkes som en Cobb-Douglas produktfunksjon med skalaelastisitet lik en:

$$(1) \qquad Y = AL^{1-\lambda}K^{\lambda},$$

der *A* er total faktorproduktivitet, som avhenger av FoU-kapitalen. Arbeidsproduktiviteten kan da uttrykkes som (dividerer med *L* på begge sider av likhetstegnet)

$$(2) \qquad \frac{Y}{L} = A\left(\frac{K}{L}\right)^{\lambda}.$$

Hvis vi tar logaritmer og kaller $y = \ln(Y/L)$ og $k = \ln(K/L)$, kan vi skrive

$$(3) \qquad y = a + \lambda k,$$

der $a = \ln A$. Opplegget for å måle kapital på foretaksnivå er beskrevet i Raknerud et al. (2007) og utnytter regnskapsdata for foretak.

I empirisk faglitteratur om sammenhengen mellom FoU, produktivitet og økonomisk vekst, er det vanlig å legge til grunn at total faktorproduktivitet, *A*, avhenger av FoU-ressursene i foretakene (evt. i hele økonomien hvis man studerer makroøkonomiske forhold). Et problem er at det ikke finnes enkelt tilgjengelige mål for akkumulerte FoU-investeringer på foretaksnivå – og heller ikke for økonomien som helhet. Et mål for FoU-kapitalen (*RK*) tilsvarende det vi har for vanlig realkapital (*K*) må derfor konstrueres. En vanlig framgangsmåte i litteraturen er som følger: La R_t betegne FoU-investeringene i i år *t*. Da er

$$(4) \qquad RK_t = (1-\delta)RK_{t-1} + R_t,$$

der RK_t er FoU kapitalen i slutten av år *t* og δ er depresieringsraten til FoU-kapitalen. Vi observerer *R*, men ikke *RK*, og har heller ingen direkte informasjon om δ. For å komme forbi dette hinderet, må vi legge flere forutsetninger til grunn. Først antar vi, i tråd med mange internasjonale studier, at $\delta = 0.15$ [8]. Hvis vi i tillegg vet noe om *RK* i et initialår ($t = 0$), kan vi estimere hele tidsserien for *RK* med basis i observasjonene av *RK* ved iterativt å bruke likning (4). I en stasjonær situasjon, hvor det ikke er noen endring i realverdien av *RK*, er $R = \delta RK$. Hvis vi antar at foretaket befinner seg i en stasjonærsituasjon i det initiale observasjonsåret, og at foretakets investeringer i FOU har vært konstante gjennom hele foretakets levetid – bortsett fra tilfeldige variasjoner fra år til år – kan vi lage et anslag på initial FoU kapital, RK_0:

$$RK_0 = \overline{R}/\delta, \text{ hvor } \overline{R} = 1/T\sum_{t=1}^{T} R_t$$

Når vi har et mål på *RK* for hvert foretak, har vi latt verdien av *RK* inngå på følgende måte i uttrykket for *a* i likning (3):

$$a_t = \beta \frac{RK_{t-1}}{L_t} + \gamma X_t + \zeta_t,$$

der X_t er en vektor av ulike typer variable, f.eks. dummy for næring, dummy for hvorvidt foretaket samarbeider med en ekstern forskningsinstitusjon, etc., β og γ er tilhørende regresjonskoeffisienter og ζ_t er et uobservert restledd, som tillates å være korrelert over tid. Dermed får vi at

$$(5) \qquad y_t = \beta(RK_{t-1}/L_t) + \gamma X_t + \lambda k_{t-1} + \zeta_t.$$

Den andre framgangsmåten for å komme rundt problemet med uobservert *RK* er å anta at δ er så liten at den kan neglisjeres. Fra (4) følger det at $RK_t - RK_{t-1} = R_t - \delta RK_{t-1}$. For små endringer, $\Delta RK_t = RK_t - RK_{t-1}$, gjelder sammenhengen $\Delta RK_t \approx RK_{t-1}\Delta \ln RK$. For neglisjerbar δ følger det da at $R_t / RK_{t-1} \approx \Delta \ln RK_t$.

Anta nå at

$$a_t = \eta \ln RK_{t-1} + \gamma X_t + \zeta_t.$$

Av det foranstående, samt relasjonene

$$\eta \equiv \frac{\partial Y_s}{\partial RK_{s-1}} \frac{RK_{s-1}}{Y_s} \text{ for alle } s,$$

og (3), følger det at vi kan skrive

$$(6) \qquad \begin{aligned} \Delta y_t &= \lambda \Delta k_{t-1} + \eta \Delta \ln RK_{t-1} + \gamma \Delta X_t + \Delta \zeta_t \\ &\approx \lambda \Delta k_{t-1} + \frac{\partial Y_{t-1}}{\partial RK_{t-2}} \frac{RK_{t-2}}{Y_{t-1}} \frac{R_{t-1}}{RK_{t-2}} + \gamma \Delta X_t + \Delta \zeta_t. \\ &= \lambda \Delta k_{t-1} + \rho \frac{R_{t-1}}{Y_{t-1}} + \gamma \Delta X_t + \Delta \zeta_t \end{aligned}$$

Her står ρ for den bedriftsøkonomiske avkastningen av FoU-kapital. I likning (6) er altså produksjonsveksten en funksjon av FoU innsatsen målt i forhold til produksjonen[9]. Merk at vi her har kommet oss rundt måleproblemet for *RK* ved å anta at depresieringen er liten. Dette er en svært vanlig framgangsmåte i internasjonal litteratur og er bl.a. brukt i Griffith et al. (2004). Merk at modellene (5) og (6) ikke er like i den forstand at i (5) er den avhengige variabelen logaritmen av produksjonen per timeverk (dvs. arbeidsproduktivitet) på *nivåform*, mens i (6) er det *endringen* i denne variabelen som inngår (dvs. relativ vekst i arbeidsproduktivitet). Vi estimerer versjoner både av likning (5) og (6) i denne rapporten. Målet for produksjon, *Y*, er tilnærmet lik nasjonalregnskapets *bruttoprodukt*.

Modellene ovenfor har lagt til grunn at vi er i stand til å måle kunnskapsnivået eller teknologinivået i foretakene ved hjelp av akkumulerte FoU-investeringer. Effekter av SkatteFUNN inkorporer vi i dette opplegget på følgende måter: (i) i ligning (5) ved at vi inkluderer FoU-kapital finansiert gjennom SkatteFUNN som en egen variabel (*skfk*), for å undersøke om denne har en annen effekt på bedriftenes arbeidsproduktivitet enn øvrig FoU kapital; (ii) i likning (6) ved at vi inkluderer en dummy variabel for hvorvidt en bedrift får skatte subsidium (*d_SKF*), for å undersøke om SkatteFUNN bedriftene har en annen produktivitetsutvikling enn andre bedrifter (gitt at vi kontrollerer for andre observerbare variable). Dette er selvsagt en forenkling og det er lett å komme opp med mange andre variable som kunne tenkes å være relevante å inkludere. Sammensetningen av arbeidsstokken i foretaket mht. utdanning er et eksempel som vi faktisk også har brukt som instrument i estimeringene av (5) og (6).

I vår tredje økonometriske modell antas produktfunksjonen å avhenge av tre typer innsatsfaktorer: kapital (*K*), antall timeverk (*L*) og produktinnsats (*M*):

$$Q = AK^{\lambda}[(\beta L)^{\rho} + M^{\rho}]^{\varepsilon/\rho},$$

der Q er produsert kvantum. Produktfunksjonen kan ses som en Cobb-Douglas funksjon, med skaleleastisiteten $\varepsilon + \lambda$, definert over kapital og en aggregert variabel input, der sistnevnte variabel er et CES aggregat over

[8] Bernstein and Mamuneas (2006) har estimert en modell for depresiering av FoU for industrinæringer med amerikanske data som tyder på enda høyere verdi av depresieringsraten.

[9] Dette er en mulig forklaring på hvorfor mange formulerer et måltall for FoU i forhold til BNP. Det går an å argumentere for et slikt måltall ut fra en helt standard empirisk modell som er mye brukt i litteraturen for studier av sammenhengen mellom forskningsinnsats og økonomisk vekst.

timeverk og produktinnsats, med substitusjonselastisitet $1/(\rho-1)$. Videre antas produsenten å stå overfor en fallende etterspørselskurve (monopolistisk konkurranse). Foretakets tilpasning av produksjonsfaktorer (K,L,M), samt priser og salg, bestemmes ved at produsentene antas a maksimere profitten.

Total faktorproduktivitet, A, antas også innenfor dette rammeverket å være en uobserverbar (latent) dynamisk prosess, mens effekter av SkatteFUNN studeres ved at selve SkatteFUNN-subsidien (relativt til foretakets lønnskostnader) tillates å påvirke A:

(7) $$a_t = \phi a_{t-1} + \tau skf_{t-1} + \zeta_t ,$$

der $a_t = \ln A_t$ (som før), skf_t er SkatteFUNN subsidien i år t målt relativt til lønnskostanden i det samme året, med tilhørende koeffisient τ, og ϕ er en autoregressiv parameter som bestemmer "hukommelsen" i a_t-prosessen. Spesielt, betyr $\phi = 1$ "uendelig" hukommelse, slik at en innovasjon vil påvirke produktiviteten i alle etterfølgende år. Vi antar altså her at SkatteFUNN-subsidien påvirker produktiviteten og lønnsomheten i foretakene direkte, gjennom leddet skf i ligning (7), uten å måtte gå veien om å måle foretakenes FoU-kapital. Andre variable som påvirker produktiviteten a_t, slik som FoU investeringer som ikke er utløst av SkatteFUNN, eller de ansattes kompetanse, inngår i (7) via de uobserverte innovasjonene ζ_t. Gjennom forutsetningen om at foretakene maksimerer sin profitt, får vi også tatt hensyn til at SkatteFUNN, via effekten på total faktorproduktivitet A, påvirker annen faktorbruk i foretakene, samt deres prissetting i produktmarkedene. A priori forutsettes det ingenting om størrelsen på de parametrene som inngår i modellen. Disse estimeres fra data.

Som vi skal komme tilbake til nedenfor, setter dette rammeverket oss i stand til å besvare spørsmål knyttet til avkastningen av selve skattesubsidien, og ikke bare avkastningen av FoU investeringer generelt. Det er nemlig en prinsipiell forskjell på spørsmålet om avkastningen av subsidien og avkastningen av prosjekter finansiert gjennom SkatteFUNN. Avkastningen av subsidien vil avhenge av to ting: (i) hvor mye foretakets FoU investeringer økes i forhold til *det de ville ha vært uten subsidien* (innsatsaddisjonalitet) og (ii) avkastningen av denne økte (marginale) investeringen. Hvis for eksempel SkatteFUNN i liten grad påvirker bedriftenes atferd, dvs. at innsatsaddisjonaliteten er lav, vil også avkastningen av subsidien være lav. Dette kan være tilfelle selv om – eller kanskje nettopp *når* – SkatteFUNN prosjektet i seg selv har høy avkastning (og dermed ville ha blitt gjennomført selv uten subsidium). I så fall endrer ikke subsidien foretakets FoU investeringer, men bare foretakts cash-flow i det året subsidien mottas (noe som kan gi eierne økt utbytte, de ansatte økt bonus, etc., men ikke økt produktivitet).

3. Resultater

Tabell 1 viser resultatene fra å estimere modell (5) basert oss på eksplisitte mål på FoU-kapitalen. Data er hentet fra SSBs FoU statistikk, registerundersøkelser, Skattedirektoratet, mv. Estimeringen er gjort på et balansert paneldatasett for årene 2001-2004, med 783 foretak, under ulike antakelser om fordelingen til restleddet ζ_t i (5). Først antar vi at ζ_t er hvit støy og estimerer modellen med GLS. Resultatene er rapportert i kolonne (1) i Tabell 1. Resultatene rapportert i kolonne (2), er basert på en estimeringsmetode (GMM) som tillater at restleddet, ζ_t, kan være korrelert over tid. Våre resultater tyder på at slik korrelasjon finnes, slik at GMM-estimatene er våre foretrukket estimater på parametrene i modellen (5).

Tabell 1. Produktivitetslikninger. Avhengig variabel: $y_t = \ln(Y_t / L_t)$

Variabel	(1)GLS		(2)GMM	
y_{t-1}	-	-	0.206	[0.051]***
RK_{t-1}	0.138	[0.378]***	0.541	[0.154]***
RK_{t-2}	-	-	-0.333	[0.085]***
$skfk_{t-1}$	0.085	[0.402]	0.429	[0.398]
$skfk_{t-2}$	-	-	-0.795	[0.642]
permanent FoU	0.048	[0.028]*	-	-
bruk av ekstern FoU	0.022	[0.012]*	-0.006	[0.017]
0-9 ansatte	-0.059	[0.039]	0.079	[0.075]
10-49 ansatte	-0.027	[0.027]	0.046	[0.055]
50-99 ansatte	-0.008	[0.023]	0.031	[0.045]
Industri	-0.201	[0.033]***	-0.717	[0.293]**
Bygg og anlegg	-0.192	[0.068]***	-	-
Varehandel	0.025	[0.047]	-0.541	[0.262]**
Tjenesteyting	0.026	[0.044]	-0.436	[0.300]
2003	0.027	[0.008]***	-	-
2004	0.097	[0.009]***	0.056	[0.016]***
konstantledd	-1.445	[0.032]***	0.009	[0.010]
Antall observasjoner	3132		1566	
Antall foretak	783		783	
Sargan test (df)	-		7.36(5)	
R2	0.12		-	

standardavvik i parentes
* signifikant på 10% nivå; ** signifikant på 5% nivå;
*** signifikant på 1% nivå
Sargan test er test av overidentifiserbare restriksjoner

En rekke sentrale parametere i modellen er ganske presist estimert. Parameteren som fanger opp effekten av FoU-kapital på produktiviteten, estimert til 0.54, hører med blant disse. Dette innbærer at den marginale avkastningen av FoU-kapital kan anslås til om lag 0.12 for en en ”representativ bedrift”, dvs. med gjennomsnittlige verdier på variablene som inngår i modellen. Dette resultatet er ikke uvanlig i lys av den internasjonale litteraturen på feltet, og avviker heller ikke mye fra Klette og Johansen (1998) som studerte industriforetak fra 1980 til 1992. Ut ifra resultatene i Tabell 1 kan det synes, ceteris paribus, som om størrelsen på foretaket ikke betyr noe for produktiviteten. Det ser imidlertid ut til å være systematiske forskjeller mellom næringene, noe en kan se ut ifra estimatene på koeffisienten til næringsdummiene (Industri, Varehandel, osv.). Mer interessant er det at det ikke er signifikante forskjeller i produktivitet mellom foretak som kjøper ekstern FoU-kompetanse og de som bare driver intern FoU. Et sentralt resultat er at variabelen for FoU-kapital finansiert via SkatteFUNN (*skfk*) ikke har noen signifikant betydning. Merk at FoU-prosjekter finansiert gjennom SkatteFUNN allerede inngår i FoU-kapitalen (*fouk*). Tolkningen av at *skfk* ikke er signifikant er derfor at det ikke er noen spesiell produktivitetseffekt av SkatteFUNN-prosjekter sammenliknet med andre FoU-prosjekter.

I Tabell 2 viser vi resultatene fra estimeringen av modell (6), dvs. når vi antar at FoU-kapitalen depresieres svært sakte. I den enkleste versjonen av modellen, estimert ved OLS, får vi et estimat på marginalavkastningen på FoU som er lik 0.12. Hvorvidt FoU-prosjektet er et SkatteFUNN-prosjekt eller ikke, spiller igjen ingen rolle, noe vi tar hensyn til ved en dummy-variabel (*d_SKF*) som er 1 hvis foretaket har SkatteFUNN-finansierte prosjekter, og 0 ellers.

Modellen rapportert i kolonne (2) i Tabell 2 er en utvidet versjon av modell (6). Den forsøker å fange opp en mye diskutert effekt av foretakenes FoU som stammer fra Schumpeteriansk innovasjonsteori, men som ofte assosieres med arbeidet til Cohen og Levinthal (1989). I følge denne teorien bidrar FoU ikke bare til økt innovasjon direkte, gjennom den nyskaping som kan oppstå, men også til at foretakene øker sin evne til å tilegne seg andres kunnskaper. Det ligger altså en læringseffekt i FoU-virksomheten som foretakene kan nyttiggjøre seg når det skal innføres ny teknologi utviklet i andre foretak. I tråd med Griffith m.fl. (2004) utvider vi modell (6) til:

$$\Delta y_t = \lambda \Delta k_{t-1} + \rho(\frac{R}{Y})_{t-1} + \mu \ln(\frac{A_f}{A})_{t-1} + \phi(\frac{R}{Y})_{t-1} \ln(\frac{A_f}{A})_{t-1} + \gamma \Delta X_t + \Delta \zeta_t \quad (8)$$

der leddet $\ln(A_f / A)$ måler avstanden i produktivitet til det mest produktive foretaket i næringen. Her forventer vi en positiv koeffisient, noe som betyr at jo lenger fra fronten foretaket er, jo sterkere produktivitetsvekst vil foretaket ha fordi det da er lettere å imitere andre. Kryssleddet, $(R/Y) \times \ln(A_f / A)$, forsøker å fange opp at egen FoU-aktivitet kan betyr noe for hvor raskt man kan innhente beste praksis. Pga. simultanitet mellom $\ln(A_f / A)_{t-1}$ og ζ_{t-1} estimerer vi (8) med instrumentering av $\ln(A_f / A)$, hvor instrumentene er laggede eksogene variable, samt andelen høyt utdannede ansatte [10] i foretaket. Mens koeffisienten for avstanden til fronten er svært presist estimert, er koeffisienten til kryss leddet ikke signifikant. Heller ikke i den siste modellvarianten i Tabell 2 er SkatteFUNN en signifikant forklaringsvariabel.

Tabell 2. Endringer i produktivitet. Avhengig variabel: $\Delta y_t = \Delta \ln(Y_t / L_t)$

Variabel	(1) OLS		(2) IV	
$(R/Y)_{t-1}$	0.126	[0.027]***	0.300	[0.190]
$\ln(A_f / A)_{t-1}$	-	-	0.821	[0.104]***
$(R/Y)_{t-1} \cdot \ln(A_f / A)_{t-1}$	-	-	0.015	[0.129]
d_SKF_t	0.008	[0.014]	0.017	[0.024]
bruk av ekstern FoU	-0.013	[0.012]	0.031	[0.022]
0-9 ansatte	-0.029	[0.020]	0.152	[0.090]*
10-49 ansatte	-0.010	[0.017]	0.095	[0.070]
50-99 ansatte	-0.010	[0.015]	0.084	[0.059]
Industri	0.006	[0.016]	-0.740	[0.288]***
Bygg og anlegg	0.041	[0.032]	-	-
Varehandel	0.027	[0.025]	-0.570	[0.249]**
Tjenesteyting	-0.017	[0.022]	-0.429	[0.351]
2003	-0.000	[0.013]	-	-
2004	0.050	[0.013]***	0.032	[0.009]***
konstantledd	0.017	[0.018]	-0.337	[0.258]
Antall observasjoner	2349		1566	
Antall foretak	783		783	
R2	0.02		0.05	

standardavvik i parentes
* signifikant på 10% nivå; ** signifikant på 5% nivå; *** signifikant på 1% nivå

Hovedkonklusjonen vi trekker av de ovenstående studiene er at prosjekter finansiert via SkatteFUNN har samme effekt på foretakenes produktivitet som andre FoU-prosjekter. Når vi skal vurdere resultatene av SkatteFUNN, kan vi ifølge disse funnene nøye oss med å anslå innsatsaddisjonaliteten og deretter regne med at avkastningen av SkatteFUNN-prosjekter er som for FoU prosjekter generelt. En slik framgangsmåte er faktisk blitt brukt en del i evalueringer av skattebaserte ordninger i andre land, jfr. Cappelen og Soland (2006, kap. 3).

Et problem er at våre analyser rapportert over bare er utført med data for foretak som er med i SSBs FoU statistikk og således omfatter foretak med minst 10 ansatte og i hovedsak de som har flere enn 50 ansatte. De aller fleste SkatteFUNN foretak har imidlertid færre enn 50 ansatte. Våre konklusjoner er derfor ikke direkte overførbare til de små foretakene. I tillegg er SkatteFUNN prosjekter bare for 2002 og 2003 med i analysen.

Vår siste modell for å analysere effekten av SkatteFUNN (jf. ligning (7) over), er estimert på data som omfatter alle aksjeselskaper i perioden 1995-2004, ikke bare de som er representert i SSBs FoU statistikk. Vi får altså nå også med oss de minste SkatteFUNN-foretaken.

Resultatene fra denne modellen viser at SkatteFUNN har en svak positiv effekt på produktiviteten i alle næringer, selv om estimatene ikke er signifikante for de fleste næringenes vedkommende. Den estimerte virkningen av en SkatteFUNN-subsidie tilsvarende 1 prosent av lønnskostnadene gitt i år $t=1$ (altså $skf_1 = 0.01$), er en økning i salg og faktorinnsats på 0.05 til 0.25 prosent ett år senere (i år $t=2$). Ved å anta at den estimerte parameteren ϕ i ligning (7) beskriver hvordan denne effekten avtar over tid, ettersom avstanden til bevilgningstidspunktet øker, kan vi anslå en tidsprofil på effektene av en gitt SkatteFUNN subsidie (se Tabell 7 i vedlegget). Dermed kan vi også estimere avkastningen på denne subsidien: Anta at kvasirenten fremover for dette foretaket *uten* SkatteFUNN ville vært som den var for dette foretaket i år $t=1$ (altså i det året det fikk SkatteFUNN subsidier). Vi kommer da fram til et estimat på forventet avkastning av SkatteFUNN ved å beregne nåverdien av den estimerte økningen i profitt (over tid) – grunnet SkatteFUNN – for ulike diskonteringsrenter og finne den renten som gir nåverdi lik SkatteFUNN subsidiens størrelse. Realavkastningen (se Tabell 3) ligger i området 2-7 prosent med lavest avkastning i tjenesteyting og høyest i industrien.

Tabell 3. Realavkastning av SkatteFUNN (i prosent)

	Industri				Tjenesteyting	
Årgang	NACE 15-24	NACE 25-29	NACE 30-33	NACE 34-36	NACE 72	NACE 74
2002	3	3	3	3	4	1
2003	3	3	3	6	3	1
2004	4	5	3	7	4	2

Igjen er det viktig å understreke at disse resultatene er meget usikre pga. få observasjoner av foretakene etter at SkatteFUNN ble innført. En kilde til usikkerhet er at vi selvfølgelig vet lite om hvordan effekten av en subsidie gitt i for eksempel 2003 vil være på fremtidige tidspunkter (si i 2010). Våre bergninger av avkastning-

[10] Dette er definert som andelen med minst 13 års utdannelse.

en legger til grunn sterke forutsetninger om at Skatte FUNN har en proporsjonal effekt på de ulike innsatsfaktorene (unntatt kapital) *ett år etter at subsidien ble gitt*. Deretter avtar effekten eksponensielt over tid, avhengig av den autorgressive parameteren ϕ i ligning (7). Denne parameteren er i og for seg empirisk bestemt og er estimert til 0.99 i alle næringene, noe som tilsier at forskjeller i total faktorproduktivitet mellom foretak (herunder eventuelle effekter av SkatteFUNN) har en svært høy grad av permanens. Men det knytter seg usikkerhet til om produktivitetseffekter av SkatteFUNN har samme permanens som andre produktivitetssjokk. Dersom effekten depresieres raskere, vil konklusjonen bli at vi overvurderer avkastningen av subsidien. På den annen side, dersom det tar flere år før effekten gjør seg gjeldende, bidrar dette isolert til at den estimerte effekten av SkatteFUNN undervurderes fordi vår data periode er så kort.[11]

[11] Hervik et al. (2006) beregner avkastningen av subsidierte prosjekter basert på foretakenes egen vurdering av framtidig avkastning. Hvis vi hadde lagt til grunn en liknende tidsprofil på SKF-prosjektenes avkastning, ville antakelig avkastningen ha blitt større enn i Tabell 3. Vi tar ikke stilling til hvilken tidsprofil som er mest realistisk, men legger i våre analyser vekt på å kommunisere resultatet av en stilisert og enkelt gjennomskuelig beregning.

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Vedlegg: The effect of R&D tax credits on firm perfomance

1 Introduction

Both economic theory as well as empirical evidence support the view that R&D plays a vital role in raising productivity on a sustainable basis. The social return on R&D investment is often higher than the private return to the investing firm. Thus in the presence of market failure, policy intervention may be justified if a well-designed intervention scheme can be implemented. For quite some time there has been a trend in OECD-countries towards relying more on fiscal policy incentives to promote R&D spending in the business sector, cf. Warda (2005). In 1996 12 OECD countries offered tax incentives for R&D expenses and by 2004 this number had increased to 18 with Norway being one of the newcomers.

R&D incentives are designed in many different ways. Some countries offer incremental schemes where only increases in R&D expenses are targeted while others have volume based incentives. A few countries have both. Although more countries have introduced tax incentives over time there is no consensus on what is best practise. Evaluations of the incentives in various countries may provide some evidence on which policies or policy mix that work well.

R&D spending in the business sector in Norway as a share of GDP is below the OECD average, in spite of a long lasting policy target of higher R&D spending. In 2002 the Norwegian government introduced an R&D tax incentive - SkatteFUNN - to stimulate R&D in the business sector. In 2002 this incentive applied only to small and medium sized enterprises (SME's) but it has been available to all firms in Norway from 2003 and onwards. SkatteFUNN provides a volume based tax credit to all firms with an R&D project that has been approved by the Research Council of Norway (NFR). A tax credit of 18 per cent of R&D-costs of the approved project (20 per cent for SME's) is deductible from the income tax payable by the firm within an upper (but not lower) project cost limit roughly equal to half a million euros. If the firm is not paying any tax or pays less tax than the tax credit, the credit is paid to the firm as if it were a grant. In Appendix A we present the SkatteFUNN scheme and its background in more detail.

The present paper is part of an evaluation of the Norwegian SkatteFUNN scheme that deals with effects of the R&D subsidies on firm performance. We focus on productivity as a measure of firm performance, while other parts of the evaluation will study effects on R&D investments, behavioural effects, and effects on innovations. When analysing the effects of R&D expenditures, and the SkatteFUNN tax incentive in particular, we use two different econometric approaches. The first is a standard approach, where a measure of productivity is regressed on firm specific variables including various R&D related variables. In our second model, we treat productivity as a latent, i.e., unobservable, process that is allowed to depend on the tax incentive. This assumption is embedded into a fully specified model for the firm where parameters of the production function as well as the demand function facing firms are estimated using a simultaneous estimation method. This model allows for heterogenous products (monopolistic competition) and firm-specific labour augmenting technological change.

Our results indicate that the productivity effects of SkatteFUNN-financed R&D projects may not be that different from ordinary R&D projects. To be more precise, we cannot reject the hypothesis that the productivity effect of SkatteFUNN is similar to that of ordinary R&D. We estimate the private rate of returns to the SkatteFUNN subsidy (tax credit), considered as a marginal investment in each firm, to about 4 per cent in 2004. We would like to emphasise that our results are based on a very short sample, since only SkatteFUNN data for 2002-2004 is included in our present study. Therefore our results are highly preliminary and should be interpreted with care.

The structure of the paper is as follows. In Section 2 we present some of the previous studies in the international literature relevant for our investigation. In Section 3 we present descriptive statistics and various econometric results on the effect of R&D and SkatteFUNN on productivity, based on the estimation of a standard Cobb-Douglas production function. In Section 4 we specify a model where the SkatteFUNN-subsidy is assumed to affect a latent variable capturing intangible capital. In Section 5 we offer some concluding comments.

2 Previous studies of R&D effects on productivity and firm performance

There are several models for the relationship between R&D activities and productivity at the firm or industry level in the economic literature. One quite general model structure is developed in Pakes and Griliches (1984) and used in Crepon et al. (1998). In these studies output is a function of input services in a fairly standard way as well as that of the productivity level of these services. If we take the standard neoclassical production function with constant returns to scale as a starting point we can express labour productivity (say value added per man-hour) as a function of capital intensity (capital per man-hour) and a productivity variable, A, that is often referred to as total factor productivity:

$$Y/L = Af(K/L). \tag{1}$$

The productivity level, A, is assumed to depend on several variables relating to market factors, industry, knowledge capital, research and development and so forth. In several studies, cf. Parisi et al. (2006) for a recent example, R&D capital and investment are not necessarily treated as the driving forces of productivity directly, but are instead assumed to influence the productivity level (A in the equation above) through product and process innovations. There is also a separate strand of literature that looks at the impact of R&D expenditures on innovation separately, cf. Mairesse and Mohnen (2004) for a recent study.

A common approach when specifying the effects of R&D on productivity is to link the productivity factor A in the equation above to the R&D knowledge stock, RK. Let us for simplicity assume that

$$A = RK^{\eta}, \tag{2}$$

where η is the elasticity of A with respect to RK, and that the knowledge stock accumulates according to

$$RK_t = (1 - \delta)RK_{t-1} + R_t,$$

where δ is the depreciation rate of the knowledge stock and R is R&D investment. If we assume the depreciation rate to be small, we can write

$$\Delta \ln A_t = \varrho(R_{t-1}/Y_{t-1}) + \beta X_t, \tag{3}$$

where ϱ is the rate of return to R&D, cf. Griffith et al. (2004). This equation says that the growth rate of productivity depends linearly on the R&D investment divided by value added, lagged one year. In econometric studies it is necessary to include other control variables, here represented by the vector X. Note that this framework assumes separability between R&D and other factors of production as opposed to the approach in Bernstein and Nadiri (1989). If an estimate (or qualified guess) of the depreciation rate is available, one can calculate the R&D capital stock, RK, according to standard PIM-procedures. In this case a direct estimation of (1)-(2) is possible. However, if one is uncertain about the depreciation rate of R&D, but is willing to assume that it is "small", model (3) is an alternative. Since little is known about the depreciation rate of R&D, both alternatives are well worth pursuing in empirical work.

Parisi et al. (2006), using Italian data, estimate the rate of return on knowledge capital to 4 per cent. This is rather low and is an interesting result for a country with relatively low R&D intensity in the business sector. Their results show that when both R&D intensity and an indicator for process innovation are included in the model, the R&D variable becomes insignificant. However, this result could be due to a simultaneity problem. Crepon et al. (1998) estimate a model with labour productivity as the dependent variable, as in (1) above. They estimate the η-parameter in equation (2) to lie in the interval 0.12-0.15 when they use OLS and GLS, but obtain rather implausible figures using two-stage least squares. In their sample of French manufacturing firms, the mean value of Y/RK is equal to 1.2, so the mean rate of return on R&D is 14 to 18 percent[1]. Similar results are found in a panel of OECD-countries, cf. Guellec and van Pottelsberghe de la Potterie (2001). This result is also within the typical range reported by Griliches (1995), which found that the median private gross return is 25 percent. Assuming a depreciation rate of 15 per cent, the net return becomes around 10 per cent.

There are few econometric studies using Norwegian firm data to estimate the rate of return on R&D at the micro level. The most well known is that of Klette and Johansen (1998) using data on manufacturing firms. They estimate a modified version of the model

[1]Note that $\eta = \frac{\partial Y_t}{\partial RK_{t-1}} \frac{RK_{t-1}}{Y_t}$, where $\frac{\partial Y_t}{\partial RK_{t-1}}$ is the rate of return on R&D.

presented earlier. In their model the knowledge stock does not accumulate according to a linear function but rather according to a log-linear one. This assumption is based on the idea that old capital and investment in new knowledge capital are complementary so that the more you have of existing knowledge, the higher is the marginal return to investment. In this way, you may have increasing returns in the production of knowledge. They do not assume a rate of depreciation a priori but instead estimate it, imposing some identifying restrictions (no increasing returns to knowledge production), to be around 0.15 which is a quite common value used in the literature, cf. also Parisi et al. (2006). The model in Klette and Johansen (1998) is not very different from equation (3) above. However, in their model lagged growth in total factor productivity is included on the right hand side. Moreover, their R&D variable is not specified as in equation (3), but includes the growth rate of R&D in addition to industry dummies, the age of the firm, plant type dummies etc. Their preferred estimate of the mean net rate of return on R&D at the firm level is 9 per cent. However, the rate of return varies considerably between industries.

In a recent study Griffith et al. (2004) develop a generalisation of the model discussed so far. Based on modern theories of endogenous innovation and growth, technology transfer is seen as a source of productivity growth for countries or industries behind the technological frontier. Furthermore, R&D activities are seen as an important factor in creating an absorptive capacity for new knowledge and technology in line with the seminal paper by Cohen and Levinthal (1989). The specification chosen by Griffith et al. (2004) is

$$\Delta \ln A_t = \varrho \frac{R_{t-1}}{Y_{t-1}} + \beta X_t + \mu \ln(\frac{A_{F,t-1}}{A_{t-1}}) + \phi \frac{R_{t-1}}{Y_{t-1}} \ln(\frac{A_{F,t-1}}{A_{t-1}}), \tag{4}$$

where A_F is the productivity level at the frontier (country or industry). The term A_F/A measures the difference from the technology frontier for each firm and can be seen as a way of capturing "catch-up" effects, so common in the literature on economic convergence of income. The last term on the right hand side captures the interaction between distance from the frontier and own R&D effort. This variable is an indicator of absorptive capacity. The idea is that the further a firm/industry/country lags behind the frontier, the more it will benefit from investing in capacity to learn from or imitate others. In their estimated equations, they also include a measure of human capital separately in addition to R&D. This variable also interacts with the technology gap variable. They find that the technology gap variable, or "catch-up" variable is not significant when entered alone ($\mu = 0$), whereas all the other terms enter significantly. Their conclusion is that disregarding interaction terms may lead to a potential mis-specification, and hence producing a bias when estimating the effects of R&D investment on productivity growth.

3 Regression models of productivity

3.1 Models specification

Following the approaches of Parisi et al. (2006), and others, we focus first on conventional regression analyses. The aim of these regression models is restricted in the sense that we do not focus on how the tax subsidy may increase R&D, but rather whether R&D capital subsidised by SkatteFUNN (henceforth denoted SKF) differs from other R&D capital. Since the price of SKF-initiated R&D is lower than the market price of R&D – because of the tax credit – one might expect that the economic return is lower. However, this applies only to the firm for which the price of marginal investment is affected by SKF. This suggests that the effect of SKF depends on the size of the R&D activity.

Our starting point is a traditional Cobb-Douglas production function with constant returns to scale:

$$Y_{it} = A_{it} L_{it}^{1-\lambda} K_{i,t-1}^{\lambda}, \tag{5}$$

where Y_{it} is production, measured as value added in constant prices, A_{it} represents the state of technology ("efficiency"), L_{it} is labour input measured by number of man-hours in period t, and $K_{i,t-1}$ measures the capital stock at the end of $t-1$. The indices $i = 1, ..., N$ and $t = 1, ..., T$ denote firm and time, respectively.

Taking logarithms of both sides of (5) and reformulating, we obtain:

$$y_{it} = a_{it} + \lambda k_{i,t-1}, \tag{6}$$

where

$$y_{it} = \ln \frac{Y_{it}}{L_{it}}, \;\; a_{it} = \ln A_{it}, \; k_{i,t-1} = \ln \frac{K_{i,t-1}}{L_{it}}.$$

The rate of technological progress of the firm, a_{it}, may be viewed as depending on (i) R&D capital per man-hour, $fouk_{i,t-1} = RK_{i,t-1}/L_{it}$, where $RK_{i,t-1}$ measures the R&D capital stock at the end of $t-1$, and (ii) SKF capital per man-hour, $skfk_{i,t-1} =$

$SKFK_{i,t-1}/L_{it}$, where $SKFK_{i,t-1}$ measures the SKF capital stock at the end of $t-1$. We also include dummies for different industrial activities, firm size, whether the firm invests in R&D permanently and whether the firm uses an external research institute for their R&D. Then the rate of technological progress can be written as

$$a_{it} = \alpha + \beta_1 fouk_{i,t-1} + \beta_2 skfk_{i,t-1} + \sum_k \gamma_k D_{it}^k + \zeta_{it}. \tag{7}$$

If the capital to labour ratio, $k_{i,t-1}$, does not vary much during the short period (in our analysis $T = 4$), we may consider it as an unobserved firm specific effects. Then inserting (7) into (6), yields

$$y_{it} = \alpha + \beta_1 fouk_{i,t-1} + \beta_2 skfk_{i,t-1} + \sum_k \gamma_k D_{it}^k + \nu_i + \zeta_{it}, \tag{8}$$

where ν_i represents a random firm specific term and ζ_{it} is white noise. With a longer time-series for each firm, it will be more suitable to include the capital to labour ratio explicitly.

Let us, more realistically, assume that the error term ζ_{it} in (8) is a first-order autoregressive process, i.e.

$$\zeta_{it} = \rho \zeta_{i,t-1} + \varepsilon_{it},$$

where

$$|\rho| < 1,\ E[\varepsilon_{it}] = 0,\ E[\varepsilon_{it}^2] = \sigma_\varepsilon^2$$

and

$$Cov[\varepsilon_{it}, \varepsilon_{jt}] = 0 \text{ if } t \neq s \text{ or } i \neq j.$$

Then, multiplying (8) by ρ and taking quasi-difference, we get a simple dynamic production equation:

$$y_{it} = \phi + \rho y_{i,t-1} + \varphi_1 fouk_{i,t-1} + \varphi_2 fouk_{i,t-2} + \varphi_3 skfk_{i,t-1} + \varphi_4 skfk_{i,t-2} + \sum_k \delta_k D_{it}^k + \varpi_i + \varepsilon_{it}, \tag{9}$$

where

$$\begin{aligned} \phi &= (1-\rho)\alpha,\ \varphi_1 = \beta_1,\ \varphi_2 = -\rho\beta_1, \\ \varphi_3 &= \beta_2,\ \varphi_4 = -\rho\beta_2,\ \varpi_i = (1-\rho)\nu_i, \end{aligned} \tag{10}$$

Let X_{it} be a vector consisting of all the regressors in (9), except $y_{i,t-1}$. Then we must have that ω_i, ε_{it} and X_{it} are independent. Equation (9) is a first order difference equation, which can be solved by repeated substitution of lagged values $y_{i,t-1}$, $y_{i,t-2}$, and so forth. If we do this, we will see that every value of y_{it} depends on all $X_{i,t-s}$, ω_i and $\varepsilon_{i,t-s}$ for $s = 0, 1, ...$ Thus the lagged endogenous variable is correlated with the firm specific effect, ω_i, which requires application of special methods for estimation.

3.2 Data and variables construction

We have constructed balanced panels of annual firm-level data for Norwegian firms, covering the period 2001–2004. The base for the sample is the R&D statistics, which are survey data collected by Statistics Norway. These data comprise detailed information about firms' R&D activities, such as total R&D expenses (divided into own-performed R&D and purchased R&D), the number of employees engaged in R&D activities and the number of man-hours worked in R&D. The sample is selected with a stratified method for firms with 10-50 employees, whereas all firms with more than 50 employees are included. The strata are based on industry classification (NACE codes) and firm size. Each survey contains about 5000 firms, although many of them do not provide complete information. Currently, data are available for 1993, 1995, 1997, 1999, and for 2001-2004. The information from the whole sample period is used for the construction of the R&D capital stocks used in this paper. However, only data for the last four years are useful for estimation of our empirical models, because the surveys conducted before and after 2001 have different frequencies.

Table 1: Overview of variables and data sources.

Variable	Interpretation	Data sources
Y	Output	accounts statistics
R	R&D investment	R&D statistics
RK	R&D capital stock	R&D statistics
$SKFK$	SKF capital stock	Tax register
L	man-hours	REE
h	share of man-hours worked by high-skilled workers	REE, NED
Derived variables:		
y	log of labour productivity: $\ln(VA/L)$	
$fouk$	R&D capital to labour ratio: RK/L	
$skfk$	SKF capital to labour ratio: $SKFK/L$	

The data from the R&D statistics are supplemented with data from four different registers: The accounts statistics, The Tax Register, The Register of Employers and Employees (REE), and The National Education Database (NED). Table 1 presents an overview of the main variables and data sources used in our study. The data sources are described in more detail in Appendix B.

Output, Y, is measured as value added at factor costs and computed as the sum of operating profits and labour costs and deflated by the consumer price index. R&D investment, R, is yearly R&D investment as it is reported in the questionnaire, deflated by the index "labour costs for R&D in private sector" (Norges Forskningsråd, 2003).

The R&D capital stock, RK, and the SKF capital stock, $SKFK$, are computed by the perpetual inventory method using a constant rate of depreciation ($\delta = 0.15$). The benchmark for the R&D capital stock at the beginning of the observation period (the beginning of 2001), RK_0, is calculated as if it was the result of an infinite R&D investment series, where, in each year, the firm's R&D investment was $R_i^* = 1/T_i \sum_t R_{it}$, i.e., the *average* R&D investment for the firm in the whole observation period. Here T_i is the number of observations for firm i and the summation is over all t where firm i is observed (also data before 2001 were used, when available for the firm). Then $RK_{i0} = R_i^*/\delta$.

Regarding the SKF capital stock, $SKFK$, the situation is different, since we know that $SKFK$ is equal to zero at the beginning of 2002. Then at the end of 2002, $SKFK$ is set equal to the R&D investment as reported in the Tax register for 2002. Thereafter a perpetual inventory method is applied for the later accumulation of SKF-subsidised R&D investments. It is important to understand the difference between R&D investments reported in the R&D statistics and in the Tax register. In the R&D statistics the total R&D investments made during a given year are reported, but in the Tax register only the R&D investments which qualify for tax credits are reported. Usually these are not higher than 4 mill. NOK (maximum 8 mill. NOK for firms buying external R&D services). By definition, $RK \geq SKFK$, although this does not always hold in the data because of measurement errors (see below).

Man-hours, L, is the sum of all individual man-hours worked by employees in the given firm according to the contract. For each firm, we distinguish between two educational groups, high-skilled and low-skilled. High-skilled workers are those who have post-secondary education, i.e., persons who have studied for at least 13 years (for a description of the educational levels, see Table 9 in Appendix B). Man hours worked by high-skilled persons are aggregated to the firm level and divided by the total number of man-hours worked in the given firm; this defines h. That is, h is the share of man-hours worked by high-skilled workers.

The individual-level data (REE and NED) are integrated into a common data base and then aggregated to the firm level. We further exclude from the sample firms with incomplete information or with extreme values for the variables of interest. We need to use the panel structure of the data in order to address the endogeneity problem that arises with respect to input choices and to be able to conduct a dynamic analysis. Hence, only firms with observations in all four years are kept. One should note that as a result of our choice, the sample used for estimation contains a high percentage of medium-large firms and firms in manufacturing, compared to the population (see Section 3.3 below). The final sample contains 783 firms.

3.3 Descriptive statistics on R&D and SKF

Table 10 (in Appendix D) shows what kind of firms are represented in the R&D statistics and the Tax register in 2004 and correspondence between these two data sources. For each of the sources we divided the firms according to the following criteria:

R&D statistics:

Represented (In/Not in the statistics): Shows how many firms that are represented in the R&D statistics in 2004.

R&D activity (R&D/No R&D): Shows how many firms that invested in R&D in 2004.

Firm size (<50, ≥ 50): divides firms according to the number of employees in 2004 (only firms with 10 or more employees are represented).

Economic activity (Manufacturing, Construction, Retail trade, Services, Others): describe distribution of the firms between different economic activities: "manuf."=NACE 15-37, "constr."=NACE 45, "retail"=NACE 50-52, "serv."=NACE 70-74.

Tax register:

Represented (SKF firm/Not SKF): Shows how many firms that have got a tax subsidy in 2004.

Firm size (0-4, 5-9, 10-49, ≥50): divides firms according to the number of employees in 2004.

Economic activity: see above.

From Table 10 (in Appendix D) we can see that out of 3284 firms who got a tax subsidy in 2004, 2334 are not included in the R&D statistics. About 65% of them, (991+533)/2334, are not included because they have less than 10 employees. At the same time, 4655 firms are represented in the R&D statistics in 2004, of which only 950 obtained a SKF tax credit. According to the survey, 860 of these had positive R&D investments in 2004, while 90 did not. For every firm who obtained a tax credit, we assumed that the firm's R&D investments was at least as high as reported in the Tax register for the given year. There are 178 observations in 2002-2004 for which the R&D investments in the R&D survey is zero, but where the tax credit is positive. For these firms, R&D investments were set equal to the investments reported in the Tax register. Moreover we checked whether firms with positive R&D investments according to the R&D statistics reported lower numbers to the R&D survey. There are 58, 261, and 350 such cases in 2002, 2003, and 2004, respectively. Also for these firms, their R&D investments were imputed and set equal to the investment reported in the Tax register.

From Table 10 we can see that small firms and firms in manufacturing and services are the main beneficiaries of SKF. Of the firms who got a tax subsidy in 2004, 38.5% (1266/3284) are in the service sector, while 37.2% (1221/3284) are in manufacturing. At the same time, the service sector represents only 12% of the observations (553/4655) in the R&D statistics. The same ratio is observed in the final sample, i.e., only 11.3% of the observations in the final sample are from the service sector and almost 64% from manufacturing. The share of small firms (10-49 employees) in the final sample is 16.6% versus 61.3% (2852/4655) in the R&D survey. Hence, medium-large firms and firms in manufacturing are overrepresented in the final sample, compared to the population covered by Table 10.

For our final sample, Table 11 (in Appendix D) reports the mean (and standard deviation) for R&D intensity, measured as a percentage of production, Y, and the R&D capital to labour ratio, $fouk$, measured as R&D capital stock per man-hour. In addition the shares of man-hours worked by high-skilled employees, h, are reported. These measures are computed both for the total sample and for the sub-sample of firms that carry out formal R&D activities. We can see that there is a large share of firms characterized by no formal R&D activity: on average, 46.2% of the firms had zero R&D activity during 2001-2004. However, if we look at each year separately, we see that the R&D activity increased by approximately 10 % from 2001-2002 to 2003-2004. If we count the number of firms in our final sample which never undertook R&D investments ($R\&D\_average = 0$), the share is much lower, only 26.2%. This could be explained by the selection rule for the final sample, where medium-large firms and firms in manufacturing are overrepresented. These firms tend to invest more in R&D. We see that the share of man-hours worked by high-educated employees is higher in the firms who report positive R&D investments. It is hardly surprising that firms who invest more intensively in R&D also employ more high-skilled workers.

Turning to the SKF data from the Tax register, we see that only 10.6% of the firms in the sample got a tax subsidy in 2002 ($d\_SKF > 0$). In 2003 and 2004 this share is more than three times higher. There are mainly two reasons for this circumstance. First, only small and medium-sized firms were eligible for tax credit in 2002, while the SkatteFUNN scheme applied to all firms in 2003 and 2004. Second, not all firms knew about the scheme and therefor did not apply. Nevertheless, after just two years the SKF capital, $SKFK$, amounts to as much as 10 % of the total R&D capital at the beginning of 2004, according to our estimates.

3.4 Results

The results of the estimation of (8) by generalised least squares method (GLS) are presented in column (1) of Table 2. The effect of the R&D capital stock per man-hour is positive and significant, while the effect of the SKF capital stock per man-hour is positive, but not significant. This result indicates that R&D capital generated by SkatteFUNN adds no more or less to a firm's productivity than other R&D projects.

Equation (9) is a first order difference equation (i.e. when $\rho \neq 0$), where the lagged endogenous variable is correlated with the firm specific effect, ω_i. The estimation of equation (9) using GLS will in this case give inconsistent estimators. The common idea of the methods for addressing this problem is to use instruments for $y_{i,t-1}$, i.e. variables that are correlated with $y_{i,t-1}$, but not with ε_{it}, and estimate equation (9) in first-differenced form in order to exclude ω_i from the equation.

In this paper we use the version of the generalised method of moments (GMM) proposed by Arellano and Bond (1991). Their framework identifies how many lags of the dependent variable that are valid instruments and how to combine these lagged levels with first differences into a potentially large instrument matrix. This procedure can be very useful in our case, since we have a very short time-series, which requires effective instruments. Furthermore, we use the skill composition of the labour stock, $h_{i,t-1}$, as an instrument for $y_{i,t-1}$, where $h_{i,t-1}$ is the share of man-hours worked by high-educated employees in firm i during period $t-1$. These variables are highly correlated, hence, $h_{i,t-1}$ is a strong instrument for $y_{i,t-1}$.

The results of the estimation by GMM are presented in column (2) of Table 2. The estimate of ρ is equal to 0.206 and is highly significant, while the coefficients for $skfk_{t-1}$and $skfk_{t-2}$ are not significantly different from zero. The effect of the ratio of R&D capital to labour is much stronger and significant than in the case of GLS. Note that the coefficients for $fouk_{t-1}$and $fouk_{t-2}$ should satisfy the constraint $\varphi_2 = -\rho\varphi_1$, see (10). This restriction is rejected by a statistical test. On the other hand, we cannot reject that the coefficients for $skfk_{t-1}$and $skfk_{t-2}$ satisfy $\varphi_4 = -\rho\varphi_3$. As to the effect of the other variables, we see that the year-dummies reveal a positive productivity growth trend, while the dummy variables for type of economic activity show that the level of productivity is different in different industries. The reported Sargan test is a test of the validity of the instrumental variables. The hypothesis being tested is that the overidentifying restrictions are valid. With a Sargan test value of 7.36 we cannot reject this hypothesis and conclude that our instruments are valid.

In our view, GMM is the most appropriate method to handle the problem of autocorrelation in the residuals. Our best estimate of the effect on labour productivity of the ratio of R&D capital to labour is therefore 0.54. From this we can calculate the mar-

Table 2: Productivity equations

Dependent variable: y_t				
Variables	(1) GLS		(2) GMM	
y_{t-1}	-	-	0.206	[0.051]***
$fouk_{t-1}$	0.138	[0.038]***	0.541	[0.154]***
$fouk_{t-2}$	-	-	-0.333	[0.085]***
$skfk_{t-1}$	0.085	[0.402]	0.429	[0.398]
$skfk_{t-2}$	-	-	-0.795	[0.642]
permanent R&D (dummy)	0.048	[0.028]*	-	-
external R&D (dummy)	0.022	[0.012]*	-0.006	[0.017]
S_10 (10-50 employees)	-0.059	[0.039]	0.079	[0.075]
S_50 (50-100 employees)	-0.027	[0.027]	0.046	[0.055]
S_100 (100-300 employees)	-0.008	[0.023]	0.031	[0.045]
manufacturing	-0.201	[0.033]***	-0.717	[0.293]**
construction	-0.192	[0.068]***	-	-
retail trade	0.025	[0.047]	-0.541	[0.262]**
services	0.026	[0.044]	-0.436	[0.300]
2003	0.027	[0.008]***	-	-
2004	0.097	[0.009]***	0.056	[0.016]***
Constant	-1.445	[0.032]***	0.009	[0.010]
Number of observations	3132		1566	
Number of firms	783		783	
Sargan test(df)	-		7.36(5)	
R^2	0.12		-	

Robust standard errors in brackets

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

The Sargan test is a test of the overidentifying restrictions.

ginal effect of R&D capital on labour productivity for an average firm (see footnote 1), i.e. using the average values (in the sample) of the R&D intensity and the ratio of R&D capital to labour (see Table 11). We then find that the marginal effect of R&D capital on labour productivity is 12%. This result is within the range of estimates obtained in international literature and does not significantly differ from the result obtained by Klette and Johansen (1998) on Norwegian manufacturing firms for the period 1980-1992.

Let us now turn to the models described in Section 2; see (3) and (4). The results are presented in Table 3. The dependent variable is the relative change in labour productivity, measured as the first difference of log value added per man-hour, $\triangle y_t$. We should note that while the original model uses a measure of total factor productivity as the dependent variable, we use instead labour productivity. However, this is justified in view of (6). The sample is the same as before. In column (1), the results for equation (3) are shown. The main variable of interest here is R&D intensity, i.e., R&D expenditures, R, divided by value added, Y. Note that we now use R&D investments and not the R&D capital stock as regressor. The reason is that we do not want to make an explicit choice with regard to the depreciation rate and the initial value of R&D capital, as is required when constructing the R&D capital stock, RK. The coefficient of R/Y, i.e. ϱ, can be interpreted as the rate of return to R&D. It is significant and equal to 0.12 which is standard in the literature. We have included a dummy for firms that got a tax subsidy (d_SKF). The estimated coefficient is far from significant. Thus there is no significant relation between the returns to R&D and whether or not the firm got a SKF subsidy. This result is in line with those of Table 2.

Table 3: Productivity growth equations

Dependent variable: $\triangle y_t$				
Variables	(1) OLS		(2) IV	
$(R/Y)_{t-1}$	0.126	[0.027]***	0.300	[0.190]
$ln(A_f/A)_{t-1}$	-	-	0.821	[0.104]***
$(R/Y)_{t-1} * ln(A_f/A)_{t-1}$	-	-	0.015	[0.129]
d_SKF_t	0.008	[0.014]	0.017	[0.024]
external R&D (dummy)	-0.013	[0.012]	0.031	[0.022]
S_10 (10-50 employees)	-0.029	[0.020]	0.152	[0.090]*
S_50 (50-100 employees)	-0.010	[0.017]	0.095	[0.070]
S_100 (100-300 employees)	-0.010	[0.015]	0.084	[0.059]
manufacturing	0.006	[0.016]	-0.740	[0.288]***
construction	0.041	[0.032]	-	-
retail trade	0.027	[0.025]	-0.570	[0.249]**
services	-0.017	[0.022]	-0.429	[0.351]
2003	-0.000	[0.013]	-	-
2004	0.050	[0.013]***	0.032	[0.009]***
Constant	0.017	[0.018]	-0.337	[0.258]
Number of observations	2349		1566	
Number of firms	783		783	
R^2	0.02		0.05	

Standard errors in brackets

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

Column (2) of Table 3 shows the results from estimating the model in Griffith et al. (2003), which is described by equation (4). The frontier variable A_F is defined as the highest level of labour productivity within each economic activity group (manufacturing, construction, retail trade, services, and others). In contrast, Griffith et al. (2004) use the "global" productivity frontier. The coefficients μ and ϕ of equation (4) correspond to the rate of convergence of productivity and the R&D-based absorptive capacity, respectively. Contrary to Griffith et al., who find that the pure catch-up variable is insignificant, while the absorptive capacity term is very significant, we find that the rate of convergence of productivity is high and very significant, while the absorptive capacity is low and statistically insignificant. This may well be due to the difference in the definition of productivity frontier, "local" imitation versus "global" imitation. Note that the pure R&D intensity effect is less precisely estimated than in the other two models shown in Table 3, but it is close to being significant at the 10 % level in a one-sided test. Note again that the SKF-dummy is clearly insignificant. An important message from Table 3 is that there does not seem to be different returns to SKF-subsidized projects, compared to ordinary R&D-projects. This is in line with the results in Table 2.

4 A structural model of supply and factor demand with R&D capital

One purpose of the regression analyses above was to identify whether the returns to R&D capital were different in firms who obtained the SkatteFUNN subsidy than in other firms. It did not, however, address the fundamental question about whether SkatteFUNN as such has any effect, either through (i) input additionality, by increasing the R&D capital in the firm, or (ii) behavioral additionality, by improving the way the R&D activity of the firm is organized.

The main purpose of the following analysis is to estimate the rate of returns on the SKF subsidy. This rate of returns is conceptually different from the rate of returns on the R&D projects financed through SkatteFUNN, which was the topic of Section 3. The return on the *subsidy* depends on two things: (i) how much the subsidy increases R&D investments compared to the (hypothetical) situation without any subsidy (i.e., input additionality) and (ii) the return on this (marginal) investment. If the subsidy to a little extent affects the firms' behaviour, i.e., there is little input additionality, then the returns on the subsidy will also be low. This may happen even if the R&D projects themselves have a high return; namely if they would have been carried out anyway. In that case, only the firms' cash flow and profits are improved, not their productivity.

In analogy to investments in fixed capital, R&D investments are often considered as a way of accumulating intangible capital. However, while many (successful) firms do not carry out formal R&D, e.g. according to the R&D statistics, fixed capital inputs are generally necessary for production. Hence, it may not be reasonable to treat tangible and intangible capital in a symmetric way, e.g. as separate multiplicative factors in a Cobb-Douglas production function. Because of the measurement problems involved in assessing the (stock of) R&D capital discussed above, we will consider the intangible capital stock as a latent (unobserved) variable. Formal R&D may be one way of accumulating such capital, but not the only one. Our approach will allow us to analyse a much more representative population of SKF-firms than covered by the R&D statistics.

In order to address the main question about the impact of the SKF subsidy on the firms' performance, it seems important to have a model framework which enables us to identify several types of possible effects. The first effect can be termed the transient effect: the immediate impact of the subsidy on the firms' accounts due to book-keeping rules. Indeed, we expect there to be such an effect, since the subsidy will, ceteris paribus, increase the profit of the firm in the year the subsidy is taken into the financial account. According to accounting guidelines for SkatteFUNN, the subsidy should be considered either as a reduction in operating costs (labour costs or other operating expenses) or as an increase in revenue.[2] In any case, the transient effect is simply a cash transfer with no real economic counterpart. The second effect is the real economic effect of the subsidy, in particular its economic rate of return. The latter is the main point of interest in this study.

4.1 A structural model of production

As shown by Marschak more than 50 years ago (see Marschak and Andrews, 1944) , production function regressions generate inconsistent parameter estimates because supply and factor demand are jointly determined by unobservable differences in efficiency across firms. The traditional solution to this problem is to try to identify valid instrumental variables, as in our analysis above. In this section we will take a somewhat different approach. Our starting point is a production function of the following type:

[2] The latter may not be common in practice, since it requires that the subsidy corresponds to an asset, depreciated over its lifetime, whereas the subsidy itself is allocated over the lifetime of the asset as an operating income.

$$Q_{it} = A_{it} K_{i,t-1}^{\gamma} \; [(\beta_{it} L_{it})^{\rho} + M_{it}^{\rho}]^{\varepsilon/\rho} \; , \; \rho < 1 \tag{11}$$

where Q_{it}, M_{it} and L_{it} are output, materials and man-hours, respectively, of firm i in year t, $K_{i,t-1}$ is the capital stock at the end of year $t-1$ (beginning of t), and A_{it} represents intangible assets, including (unobserved) $R\&D$ capital. The scale elasticity is $\varepsilon + \gamma$ and the elasticity of substitution between labour and materials is $1/(\rho - 1)$. Capital is assumed quasi-fixed: capital input in year t is given by the capital stock at the end of $t-1$, $K_{i,t-1}$.

The production function can be seen as a Cobb-Douglas function in capital and an aggregate input variable obtained using a CES-aggregation function. The specification (11) allows heterogeneity in labour productivity through β_{it}: A positive change in β_{it} can be interpreted as a labour-augmenting innovation. On the other hand, Hicks-neutral changes in efficiency are picked up by A_{it}. Both A_{it} and β_{it} may shift over time and vary across firms.

If the parameters in (11) were known and $\beta_{it} \approx 0$, which corresponds to Cobb-Douglas, one could derive the unobserved efficiency variable A_{it}. Then interesting relations could be uncovered by regressing $\ln A_{it}$ on RD, $SKFK$, etc., gsimilar to our previous regressions. However, since the parameters in (11) have to be estimated in a first stage, $\ln A_{it}$ must be imputed, which leads to biased estimators due to measurement errors. Moreover, since K_{it}, L_{it} and M_{it} are simultaneously determined with Q_{it}, we are faced with an endogeneity problem, see Griliches and Mairesse (1998) for a survey. To address this problem, we will here analyse a full-specified economic model that explicitly uses the system of equations derived from optimising supply and factor demand.

First, assume monopolistic competition between a large number of producers of a differentiated good, where each producer faces a demand function of the form

$$Q_{it}^{D} = \Phi_t P_{it}^{-e}, \; e > 1, \tag{12}$$

where Φ_t is common to all firms in the industry and e is the demand elasticity. A justification for, and interpretation of, the demand function (12) is found in Dixit and Stiglitz (1977)[3]. Profit maximization implies the following expressions for sales, $S_{it} =$

[3] In their derivation, $e = 1/(1-\widetilde{\rho})$, where $\widetilde{\rho} \in (0,1)$ is the elasticity of substitution between the demand for the different varieties of the product, whereas the term Φ_t captures the aggregate demand for the industry's product.

$P_{it}Q_{it}$, and (short-run) factor demand, M_{it} and L_{it} (given $K_{i,t-1}$):

$$\begin{bmatrix} \ln S_{it} \\ \ln M_{it} \\ \ln L_{it} \end{bmatrix} = \begin{bmatrix} \frac{e-1}{\varepsilon+e-e\varepsilon} \\ \frac{e-1}{\varepsilon+e-e\varepsilon} \\ \frac{e-1}{\varepsilon+e-e\varepsilon} \end{bmatrix} \ln A_{it} + \begin{bmatrix} -\frac{\varepsilon(e-1)}{\varepsilon+e-e\varepsilon} \\ -\frac{\varepsilon(e-1)}{\varepsilon+e-e\varepsilon} - r \\ -\frac{\varepsilon(e-1)}{\varepsilon+e-e\varepsilon} - r \end{bmatrix} \ln c_{it} - \begin{bmatrix} 0 \\ 0 \\ r \end{bmatrix} \ln \beta_{it}$$

$$+(r-1) \begin{bmatrix} 0 \\ \ln w_t^m \\ \ln w_t^l \end{bmatrix} + \mathbf{1} \frac{\gamma(e-1)}{\varepsilon + e - e\varepsilon} \ln K_{i,t-1} + \begin{bmatrix} e_{it,S} \\ e_{it,M} \\ e_{it,L} \end{bmatrix} \tag{13}$$

where

$$c_{it} = \left[(w_t^l / \beta_{it})^r + (w_t^m)^r \right]^{\frac{1}{r}} \tag{14}$$

can be interpreted as an aggregate factor price index and $r = \rho/(\rho - 1)$. Furthermore, w_t^l and w_t^m are the prices of labour and materials, respectively – both assumed common for all firms in the same industry at the two digit NACE level. Moreover, $\mathbf{1} = [1, 1, 1]'$ and $e_{it,k}$ is white noise, $k = S, M, L$.

Capital adjustments Assume that there exist adjustment costs of capital. Given that the adjustment cost function is weakly convex (with a possible kink at zero due to partial irreversibilities), then the actual capital stock at the end of year t, K_{it}, and the frictionless capital stock, K_{it}^*, will have the same long run growth rate (see Bloom et al., 2007). That is,

$$\ln K_{it} = \ln K_{it}^* + \text{error},$$

where K_{it}^* is the capital stock the firm would choose with costless reversibility, i.e., if the marginal revenue of capital is equal to the user cost, and the error term is stationary. It can be shown that K_{it}^* is given by

$$\ln K_{it}^* = \text{constant } + \kappa_c \ln c_{it} + \kappa_A \ln A_{it} + \kappa_q \ln q_{Kt},$$

for fixed coefficients κ_c, κ_A and κ_q, and where q_{Kt} is the user price of capital. Assume that the short-run dynamics of capital formation can be described by ”gap technology”:

$$\Delta \ln K_{it} = (\pi - 1)(\ln K_{i,t-1} - \ln K_{it}^*) + e_{it,K}, \tag{15}$$

where $|\pi| < 1$ is an autoregressive coefficient. The resulting system of equations can then be written as

$$y_{it} = \Gamma \alpha_{it} + \Pi \ln K_{i,t-1} + d_t + e_{it}, \tag{16}$$

where

$$y_{it} = \left[\ \ln S_{it}, \quad \ln w_t^m M_{it}, \quad \ln w_t^l L_{it}, \quad \ln K_{it}\ \right]'$$

is the vector of observable variables,

$$\alpha_{it} = [\ln A_{it}, \ln c_{it}, \ln \beta_{it}]'$$

is a vector of latent variables, including intangible assets, A_{it} (which incorporates R&D capital), d_t is a vector with industry specific intercepts which depends on common prices and demand conditions (at the two digit NACE level), and

$$e_{it} = [e_{it,S}, e_{it,M}, e_{it,L}, e_{it,K}]' \text{ and } e_{it} \sim i.i.d.(0, \Sigma),$$

where Σ is a general covariance matrix. The coefficient matrices Γ and Π are defined as

$$\Gamma = \begin{bmatrix} \frac{e-1}{\varepsilon+e-e\varepsilon} & -\frac{\varepsilon(e-1)}{\varepsilon+e-e\varepsilon} & 0 \\ \frac{e-1}{\varepsilon+e-e\varepsilon} & -\frac{\varepsilon(e-1)}{\varepsilon+e-e\varepsilon} - r & 0 \\ \frac{e-1}{\varepsilon+e-e\varepsilon} & -\frac{\varepsilon(e-1)}{\varepsilon+e-e\varepsilon} - r & -r \\ (1-\pi)\kappa_A & (1-\pi)\kappa_c & 0 \end{bmatrix}, \Pi = \begin{bmatrix} \frac{\gamma(e-1)}{\varepsilon+e-e\varepsilon} \\ \frac{\gamma(e-1)}{\varepsilon+e-e\varepsilon} \\ \frac{\gamma(e-1)}{\varepsilon+e-e\varepsilon} \\ \pi \end{bmatrix}. \tag{17}$$

Note that a shift in intangible assets, A_{it}, has the same (proportional) effect on sales, material input and labour input.

Identification While the coefficients π and $\gamma(e-1)/(\varepsilon+e-e\varepsilon)$ in the parameter vector Π are identified, it is not possible to identify the parameters of Γ defined in (17). The reason is that the vector α_{it} is unobservable. Hence, the term $\Gamma\alpha_{it}$ in equation (16) is observationally equivalent to $\widetilde{\Gamma}\widetilde{\alpha}_{it}$, where $\widetilde{\Gamma} = \Gamma\mathcal{R}$ and $\widetilde{\alpha}_{it} = \mathcal{R}^{-1}\alpha_{it}$ for any invertible matrix $\mathcal{R}$. Our structural model does, however, imply a number of useful restrictions on $\mathcal{R}$, which we now shall examine. First, let

$$\mathcal{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}.$$

In order for $\widetilde{\Gamma}$ to have the same structure as Γ, one must have

$$\widetilde{\Gamma} = \begin{bmatrix} \widetilde{\theta}_1 & \widetilde{\theta}_2 & 0 \\ \widetilde{\theta}_1 & \widetilde{\theta}_3 & 0 \\ \widetilde{\theta}_1 & \widetilde{\theta}_3 & \widetilde{\theta}_4 \\ \widetilde{\theta}_5 & \widetilde{\theta}_6 & 0 \end{bmatrix},$$

with $\widetilde{\theta}_1 > 0$ and $\widetilde{\theta}_2 < 0$. By considering the equation $\widetilde{\Gamma} = \Gamma\mathcal{R}$, we easily derive the following zero-restrictions on $\mathcal{R}$:

$$\mathcal{R}= \begin{bmatrix} r_{11} & r_{12} & 0 \\ 0 & r_{22} & 0 \\ 0 & 0 & r_{33} \end{bmatrix}.$$

An increase in β_{it}, i.e., a labour-augmenting innovation, reduces c_{it}. Thus $\ln c_{it}$ and $\ln \beta_{it}$ should be negatively correlated. On the other hand, we will assume that $\ln A_{it}$ is independent of $(\ln c_{it}, \ln \beta_{it})$, i.e., neutral efficiency shocks are independent of labour augmenting innovations. Then $r_{12} = 0$ and $\mathcal{R}$ becomes a diagonal matrix.[4] The restriction $r_{12} = 0$ enables us to identify Γ up to an arbitrary proportionality factor for each of its columns (i.e. r_{11}, r_{22} and r_{33}, respectively).

Stochastic specification of $\boldsymbol{\alpha}_{it}$ We assume, provided the firm enters the sample at $t = 1$, that

$$\begin{aligned} \alpha_{it} &= \begin{cases} \alpha_{i1} & t = 1 \\ \Phi\alpha_{i,t-1} + \eta_{it} & t = 2, ..., T, \end{cases} \\ \alpha_{i1} &\sim \mathcal{IN}(0, \Sigma_1),\ \eta_{it} \sim \mathcal{IN}(0, \Sigma_\eta), \end{aligned} \tag{18}$$

where Φ is a 3×3 matrix of AR coefficients, $\eta_{it} = (\eta_{it,1}, \eta_{it,2}, \eta_{it,3})'$ is an innovation vector with covariance matrix Σ_η, and the covariance matrix Σ_1 of α_{i1} characterizes the cross-sectional heterogeneity across firms in their first observation year, i.e. the *initial* heterogeneity. Heterogeneity between firms in any later year, t, can be decomposed into the remaining impact of the initial condition α_{i1}, i.e., $\Phi^t\alpha_{i1}$, and the *cumulated innovations*, $\sum_{s=0}^{t-2}\Phi^s\eta_{it-s}$. In order to obtain identification, both the initial condition, α_{i1}, and the subsequent innovations, η_{it}, must have a mean of zero, since any non-zero mean will be indistinguishable from the industry-wide intercept d_t in (16). Moreover, to identify Γ we standardize α_{it} by requiring that the innovations, η_{it}, have unit variance, i.e.,

$$\boldsymbol{\Sigma}_\eta = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & \sigma_{cw} \\ 0 & \sigma_{cw} & 1 \end{bmatrix}, \tag{19}$$

where σ_{cw} is the correlation between $\ln c_{it}$ and $\ln \beta_{it}$. We then obtain full identification from the restrictions $\widetilde{\theta}_1 > 0$, $\widetilde{\theta}_2 < 0$ and $\sigma_{cw} < 0$, where the last restriction follows

[4] Assume, conversely, that $r_{12} \neq 0$. Then the first component of $\widetilde{\alpha}_{it}$ is correlated with the other components, while the first component of α_{it} *is not* correlated with any of the other components (given the stated assumption that $\ln A_{it}$ is independent of $(\ln c_{it}, \ln \beta_{it})$.

because an increase in β_{it} reduces c_{it} – see (14). The restriction stated above that $\ln A_{it}$ is independent of $(\ln c_{it}, \ln \beta_{it})$ then implies that

$$\ln A_{it} = \phi \ln A_{i,t-1} + \eta_{it,1}, \tag{20}$$

where $\eta_{it,1}$ is uncorrelated with $(\eta_{it,2}, \eta_{it,3})$.

4.2 The effect of R&D subsidies

Let $SKFS_{it}$ denote the SKF tax subsidy obtained by firm i in year t. Our previous, reduced form regressions indicate that if $SKFS_{it} > 0$, then any persistent effects on the dependent variables are transmitted through an increase in R&D capital. Thus *performance additionality* requires *input additionality.* This can be modelled as a shift in the equation (20) for A_{it} as follows

$$\ln A_{it} = \phi \ln A_{i,t-1} + \tau skfs_{i,t-1} + \eta_{1,it}, \tag{21}$$

where τ is the coefficient expressing the tax subsidy's effect on $\ln A_{it}$ and

$$skfs_{i,t-1} = \frac{SKFS_{i,t-1}}{w^l_{i,t-1} L_{i,t-1}} \tag{22}$$

is the subsidy measured relative to the labour costs in the period the subsidy is given. This "normalization" is chosen as a simple way of incorporating proportionality between the relative change induced by the subsidy, on the one hand, and the size of the subsidy relative to the size of the firm, on the other. Recall that the dependent variables are modelled on log-form, which means that any change can be interpreted as relative change. The choice of labour costs as "numeraire" is reasonable, since R&D subsidies are usually thought of as a subsidy of labour.

The variable $\ln A_{it}$ corresponds to intangible capital, which is determined, among other things, of the firm's R&D activity, and hence SKF. To distinguish between any persistent effect of SKF, on the one side, and the transient cash flow effect on the other, the tax subsidy enters (21) with a lag. In contrast to the reduced form models in Section 3, we do not here attempt to measure R&D capital directly by explicitly accumulating R&D investments. Instead, we consider A_{it} as a latent variable. Then, if the R&D subsidy, $SKFS_{it}$, leads to shift in the latent productivity process, A_{it}, we may interpret this as *additionality.* This is equivalent to $\tau > 0$. On the other hand, if $\tau = 0$, there is no additionality. That is, there is no positive shift in the expected value of $\ln A_{i,t+1}$ when $SKFS_{it} > 0$.

More specifically, in the period just after the subsidy is given, the effect on log sales by $SKFS_{it}$ is given by

$$\Delta \ln S_{i,t+1} = \frac{\partial \ln S_{i,t+1}}{\partial skfs_{it}} skfs_{it} = \lambda_1 skfs_{it}, \text{ where } \lambda_1 = \frac{\tau(e-1)}{\varepsilon + e - e\varepsilon}, \tag{23}$$

using (21) and (16)-(17). Furthermore, from (17),

$$\Delta \ln S_{i,t+1} = \Delta \ln M_{i,t+1} = \Delta \ln L_{i,t+1},$$

and

$$\Delta \ln K_{i,t+1} = \frac{\partial \ln K_{i,t+1}}{\partial skfs_{it}} skfs_{it} = \rho_1 skfs_{it}, \text{ where } \rho_1 = \tau\kappa_A(1-\pi). \tag{24}$$

The AR-coefficient ϕ determines the long-term effect of the subsidy, as we will discuss below.

Inference To obtain valid statistical inference in this model, $SKFS_{it}$ needs to be a weakly exogenous variable, which means that the distribution of $SKFS_{it}$, given all the observed and latent variables of the model up until time t, only depends on the observed variables. Thus $SKFS_{it}$ may depend on A_{it}, but only through observed variables at time t, e.g. y_{it}. On the other hand, $SKFS_{it}$ is not allowed to depend on future productivity shocks, e.g. $\eta_{i,t+1}$. This assumption is similar to the conditional independence assumption, which is standard in the treatment effects literature (see Rosenbaum and Rubin, 1983; and Imbens, 2004, for an overview).

The assumption of weak exogeneity is necessary to ensure that the *cause* of the subsidy is not misinterpreted as an *effect* of it. For example, if the firms with high R&D intensity self-select into the SkatteFUNN scheme, one cannot interpret a positive statistical association between A_{it} and $SKFS_{it}$ as an effect of the tax subsidy. The assumption that $SKFS_{it}$ affects A_{it} with a lag is essential here. If the weak exogeneity assumption holds, then $SKFS_{it}$ is independent of $\eta_{i,t+1}$, and the effect of $SKFS_{it}$ can, in principle, be identified by its impact on $\Delta \ln A_{it}$. Loosely speaking, the basis for identifying the effects of the subsidy is not differences in the performance between firms that obtained the subsidy and those who did not, but the change in the performance before and after the subsidy was given. Thus the availability of panel data is essential for identification of our parameters of main interest.

Our model can be represented on a state space form in terms of the dependent variables y_{it}. The state space form can be described as a conditional Gaussian model, which we estimate by pseudo maximum likelihood, as described in Harvey (1989). The reason that the distribution of y_{it} is not exactly Gaussian, is the appearance of the lagged endogenous variable $L_{i,t-1}$ in the transition equation (21) – see (22).

Transient effects As described above, firms are obliged to adjust their cost and income statements to incorporate the subsidy. Obviously the positive effect on a firms' profits due to the cash flow effect of the subsidy is not an additionality effect. We shall now give a more formal treatment of the transient effect.

In the above model, prices were assumed to be market prices. On the other hand, the accounts data incorporate the tax subsidy as a lump sum transfer. Therefore the cost and income statements in the accounts may not reflect market prices. Let

$$Y_{it} = (S_{it}, w_t^l L_t, w_t^m M_t, K_{it}).$$

We assume that the k'th component of Y_{it} is measured in the accounts through the variable, $Y_{it,k}^*$, as follows:

$$Y_{it,k} = Y_{it,k}^* + \tau_k^y SKFS_{it},\ k = S, M, L. \tag{25}$$

In (25), $k = S, M$ and L correspond to operating income, material and labour costs, respectively. $\tau_S^y \leq 0$ is the share of the subsidy counted as an *increased* operating income in the account, $\tau_M^y \geq 0$ is the share of the subsidy which is counted as *reduced* material costs, whereas $\tau_L^y \geq 0$ is the corresponding share for labour costs. For example, if $\tau_L^y > 0$ the wage costs in the accounts underestimate the real cost of labour (measured at market prices). That these shares are the same for all firms should be viewed as a simplification. In the presence of idiosyncracies across firms and over time in the book-keeping practice with regard to the tax subsidy, the parameters τ_k^y may pick up a common pattern. These parameters are not of interest per se. They are nuisance parameters, which, nevertheless, may contribute to the identification of the parameters of interest related to SKF. A derivation of an approximate likelihood function in terms of the observed variables $\ln Y_{it,k}^*$ is given in Appendix C.

4.3 Data and variable construction

We have constructed panels of annual firm level data for Norwegian firms in selected industries. Only industries with a significant R&D intensity according to the share of the firms in each industry who obtained the SKF subsidy are considered in this analysis, namely NACE 15-36 (i.e. manufacturing) and two service industries: NACE 72 (Computer and related activities) and NACE 74.1-74.4 (Legal, accounting, book-keeping activities and consulting). For manufacturing, we divide the different industries into four main groups when estimating our econometric model: NACE 15-24 (food& tobacco, textiles, leather, pulp&paper, wood and chemical products), NACE 25-29 (plastics, metals, minerals and machinery), the high-tech industry NACE 30-33 (manufacture of electrical and optical equipment), and NACE (34-36) (transport equipment and furniture). The data sources are described in Appendix B.

Our observation unit is the firm: A firm is defined as "the smallest legal unit comprising all economic activities engaged in by one and the same owner" and corresponds in general to the concept of a company (see Statistics Norway, 2000). The population of stock companies is a subset of all manufacturing firms and comprises about 90% of total man-hours in manufacturing in 2003. A stock company should not be confused with a publicly traded company, which often refers to a consolidated group; i.e., a parent company with subsidiaries.[5]

A firm may consist of one or more establishments (plants). The establishment is the geographically local unit doing economic activity within an industry class. About 80-90 per cent of the firms in our database are single-establishment firms.

Our model contains six variables: sales, man-hours, materials, capital, R&D subsidy (tax credit) from SKF and wage costs (cf. Table 4). In general, all costs and revenues are measured in nominal prices, and incorporate direct taxes and subsidies, except VAT. We have deflated the nominal variables with industry-wide deflators.

The method for calculating the capital stocks in current prices is based on combining book values from the financial accounts with gross investment data.[6] Our econometric

[5] The parent company must in addition to its (unconsolidated) account also provide an consolidated account that treats the parent and the subsidiaries as one economic unit, i.e. one group (see Hawkins, 1986, p. 96). The Norwegian data are non-consolidated data so that the parent company and the subsidiaries are treated as separate firms (which, of course, may reside in different industries).

[6] See Raknerud et al. (2007) for technical details and an evaluation of the data quality.

Table 4: Variables and data sources.

Variable name	Interpretation	Data sources
S	sales	accounts statistics
L	man-hours	REE
$w^l L$	labour costs	accounts statistics
M	materials*	accounts statistics
$w^l M$	material costs	accounts statistics, structural statistics
K	capital	accounts statistics, structural statistics
$SKFS$	R&D tax subsidy from SKF	tax register
$skfs$	tax subsidy to labour costs ratio	tax register, accounts statistics

*Materials are calculated as total operating costs less the sum of labour costs, depreciation and operational leasing (e.g. rents), in fixed prices.

model contains an aggregate capital variable for each firm, constructed as a Törnqvist volume index with time-varying weights. The weights are common to all firms in the same industry[7]. An important property of the Törnqvist index is that it can be formulated equivalently in terms of the rental costs of capital (see OECD, 2001). Thus it is possible to aggregate owned capital (which are taken into the firm's balance sheet) and leased capital by summing over the corresponding rental costs.[8]

Our observation period is the 10-year period 1995-2004. Initially *all* firms in an industry that were operating during this period were included in the sample. Some "cleaning" of the data was performed. A firm was excluded from the sample if: (i) the value of a variable is missing for two or more subsequent years; (ii) the firm disappears from the raw data file and then reappears more than once; or (iii) the firm is observed in a single year only. These trimming procedures reduced the data set by 15-20 per cent. Some summary statistics describing our final sample are presented in tables 12-15 (in Appendix D).

The empirical analysis is carried out for each of the six groups of industries separately. Time-varying industry-specific intercepts at the two-digit NACE level were included. Thus heterogeneity within each group of industries due to systematic differences in factor prices and demand conditions are accounted for in our empirical model.

[7]Capital is divided into two groups of assets in the database: (i) Buildings (which have long service lives) and (ii) Equipments (with small or medium service lives).

[8]The rental cost of capital for capital of type j is calculated as $R_{it}^j = (\iota + \delta_j) q_t^j K_{it}^j$,where where j is either Equipments or Buildings and q_t^j is the corresponding purchasing price. The median depreciation rate δ_j are about 0.2 for Equipments and 0.05 for Buildings. These are obtained from the accounts statistics, see Raknerud et al. (2007). The real rate of return, ι, which we calculated from the average real return on 10-year government bonds in the period 1996-2002, is 4.2 per cent.

4.4 Results

The results for the key parameter τ determining the persistent effect of $SKFS_{it}$ on efficiency, A_{it}, are given in Table 5. We see that in all the industries the estimate of τ is positive, ranging from 0.12 in NACE 74 (Services) to 1.01 in NACE 34-36. However, the parameter is significantly different from zero only for NACE 72 . The overall results in Table 5 is that SkatteFUNN generally has a weak, but positive effect on a firm's efficiency as measured by intangible capital ("efficiency"), A_{it}.

The results regarding the transient-effects parameters $\tau_S^y, \tau_M^y, \tau_L^y$, give no clear picture. It seems that the short term effect on material costs, which is a broad category incorporating all operating expenses except labour and capital costs, dominates that of labour costs (recall that a positive τ_M^y and τ_L^y means that the subsidy leads to reduced material costs and labour costs, respectively).

Table 5: Parameter estimates. St. errors in parenthesis

Sector	NACE	Parameter τ	τ_S^y	τ_M^y	τ_L^y
Manufacturing	15-24	0.57 (0.36)	-0.00	0.08	0.00
	25-29	0.59 (0.37)	-0.00	0.59	0.01
	30-33	0.34 (0.45)	-0.00	0.27	0.09
	34-36	1.01 (0.65)	-0.00	0.38	0.00
Services	72	0.37 (0.12)	-0.00	0.05	0.00
	74	0.12 (0.14)	-0.00	0.00	0.00

The parameter estimates reported in Table 6 give an indication of the effect on the SKF subsidy on the observable variables sales, labour, materials and capital. First, the parameter λ_1 can be interpreted as the percentage change in sales, labour and material inputs in period $t+1$ if the variable $skfs_{it}$, i.e. the ratio of the tax subsidy, $SKFS_{it}$ to wage costs, $w_t^l L_{it}$, is one percent, cf. (23). The results in Table 6 indicate that a tax subsidy equal to 1 percent of total labour costs, leads to a proportional increase in sales and variable inputs in the range of 0.05 to 0.25 percent. The parameter ρ_1 shows the corresponding effect on capital, cf. (24). This effect seems to be roughly 1/3 of the corresponding λ_1 coefficient, indicating a slower adjustment of capital than the other production factors, as expected.

The estimates of the coefficient of lagged capital, $\gamma(e-1)/(\varepsilon+e-e\varepsilon)$, cf. (17), are significantly less than one in all the industries. Thus, either the elasticity of scale, $\gamma+\varepsilon$, is less than one or firms have market power, $e < \infty$. Note that neither γ, ε or e are identifiable.

The estimated autoregressive coefficients π and ϕ of capital, $\ln K_{it}$, and efficiency, $\ln A_{it}$, respectively, are quite similar across all the industries. The estimates of π lie between 2/3 and 3/4, whereas ϕ is very close to one. The latter shows that technological innovations have a very high degree of persistence, i.e., $\ln A_{it}$ is close to a random walk. This is consistent with Gibrat's law that firms' growth rates are independent of firm size (see Sutton, 1997).[9]

Table 6: Parameter estimates, continued. St.errors in parenthesis

		Parameter				
Sector	NACE	λ_1	ρ_1	$\frac{\gamma(e-1)}{\varepsilon+e-e\varepsilon}$	π	ϕ
Manuf.	15-24	0.14 (0.09)	0.037 (0.02)	0.13 (0.01)	0.76 (0.01)	0.99 (0.01)
	25-29	0.15 (0.10)	0.045 (0.03)	0.13 (0.01)	0.72 (0.01)	0.98 (0.01)
	30-33	0.08 (0.09)	0.03 (0.03)	0.07 (0.02)	0.66 (0.03)	0.99 (0.01)
	34-36	0.26 (0.17)	0.07 (0.05)	0.15 (0.01)	0.74 (0.02)	0.98 (0.01)
Services	72	0.15 (0.05)	0.05 (0.02)	0.36 (0.01)	0.73 (0.01)	0.95 (0.01)
	74	0.04 (0.05)	0.01 (0.02)	0.19 (0.01)	0.66 (0.01)	0.95 (0.01)

We can use the estimated model to predict the effects on future sales (S), man-hours (L) and capital (K) of the SKF subsidies. Table 7 shows the predicted effects after 1,2, 3 and 10 years for different categories of firms in manufacturing who got the SKF subsidy in 2004. Each firm is categorized in the table according to employment, so that each employment interval contains 10 percent of the firms. The share of total SKF subsidy and the share of total employment for each category are also shown (in columns 2 and 3). The two last rows in the table sum up the results by calculating two weighted averages, using share of total employment and share of total SKF subsidy as weights, respectively. We see that when weighted by employment share, the resulting "average" SKF-firm obtained a tax subsidy equal to 1.5 percent of its labour costs. We predict that after one year, this amount of subsidy leads to an increase in sales and man-hours of 0.2 percent. The effect is unchanged after 10 years. For capital (K), the effect after one year is 0.1 percent, gradually increasing to 0.2 percent after 10 years. When weighted, instead, by the share of tax subsidy, the resulting "average" firm obtained a tax subsidy equal to 5.9 percent of its

[9] Other studies that model firm growth as a stochastic process with a high degree of persistence comprise Klepper (1996), Klette and Griliches (2000) and Klette and Kortum (2004).

labour costs in 2004. The predicted increase in sales, man-hours and capital is 0.8 percent after 10 years (with capital adjustment being slower than for sales and man-hours). The table also tells us something interesting about cross-sectional heterogeneity: 10 percent of the SKF-firms have 4 employees or less. They accounted for 7.4 percent of the SKF subsidy in 2004, but only 0.4 percent of the employment, and their SKF subsidies as a share of their labour costs, constituted as much as 27.1 percent. On the other hand, 10 percent of the firms have more than 150 employees. They accounted for 53 percent of the employment, but only 9.9 percent of the SKF subsidy in 2004. For these firms, the tax subsidy constituted less than 1 percent of their labour costs and the effects of SKF on sales, man-hours and capital are negligible, according to our predictions.

Table 7: Estimated growth (in percent) of sales, man hours and capital for manufacturing firms who got a SkatteFUNN subsidy in 2004.

No. of	$SKFS$	Empl.		1 year later		2 years later		3 year later		10 years later	
empl.	share	share	$skfs$	S,L	K	S,L	K	S,L	K	S,L	K
≤ 4	7.4	0.4	27.1	3.8	1.0	3.9	1.7	3.9	2.3	3.6	3.6
(4; 7]	7.8	1.0	12.3	1.7	0.5	1.8	0.8	1.8	1.0	1.6	1.6
(7; 11]	9.8	1.6	9.3	1.3	0.3	0.0	0.6	1.3	0.8	1.2	1.2
(11; 15]	8.5	2.4	5.7	0.8	0.2	0.8	0.4	0.8	0.5	0.8	0.8
(15; 21]	10.2	3.2	4.7	0.7	0.2	0.7	0.3	0.7	0.4	0.6	0.6
(21; 28]	10.7	4.6	3.3	0.5	0.1	0.5	0.2	0.5	0.3	0.4	0.4
(28; 41]	10.2	5.8	2.4	0.3	0.1	0.3	0.2	0.3	0.2	0.3	0.3
(41; 66]	12.3	10.0	1.9	0.3	0.1	0.3	0.1	0.3	0.2	0.3	0.3
(66; 150]	12.9	18.0	1.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
> 150	9.9	53.0	0.4	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Weighted	(by empl. share)		1.5	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.2
average:	(by SKFS share)		5.9	0.8	0.2	0.7	0.4	0.8	0.5	0.8	0.8

Note: Only firms that got the SkatteFUNN subsidy in 2004 are in the sample.

4.5 The rate of return on the SKF subsidy

Let us now address the important question about the rate of return on the SKF subsidy. Our analysis investigates the partial effect of a change in one variable, $skfs_{it}$, keeping all the other exogenous variables fixed. First, using (21) and (16)-(17), the subsidy's impact on log sales after h years, denoted, $\Delta_h \ln S_{i,t+h} = \ln S_{i,t+h} - \ln S_{it}$, is given by the differential

$$\begin{aligned}\Delta_h \ln S_{i,t+h} &= \frac{\partial \ln S_{i,t+h}}{\partial skfs_{it}} skfs_{it} \\ &= \frac{\tau(e-1)}{\varepsilon + e - e\varepsilon}\phi^{h-1} skfs_{it} + \frac{\gamma(e-1)}{\varepsilon + e - e\varepsilon}\Delta_h \ln K_{i,t+h-1},\ h = 1, 2, ..\end{aligned}$$

where

$$\begin{aligned}\Delta_h \ln K_{i,t+h} &= \frac{\partial \ln K_{i,t+h}}{\partial skfs_{it}} skfs_{it} \\ &= \tau\kappa_A(1-\pi^h)\phi^{h-1} skfs_{it}, h = 1, 2, ...\end{aligned}$$

Note that $\Delta_h \ln S_{i,t+h}$ and $\Delta_h \ln K_{i,t+h}$ can be interpreted as the relative change in sales and capital, respectively, in year $t+h$ resulting from a tax subsidy in year t ($SKFS_{it} > 0$), compared to the (hypothetical) values of $S_{i,t+h}$ and $K_{i,t+h}$ when $SKFS_{it} = 0$. We see from the two above equations that

$$\begin{aligned}\Delta_h \ln S_{i,t+h} &= \lambda_h skfs_{it} \\ \Delta_h \ln K_{i,t+h} &= \rho_h skfs_{it},\end{aligned}$$

where λ_1 and ρ_1 were given in (23) and (24) and

$$\lambda_h = \lambda_1\phi^{h-1} + \frac{\gamma(e-1)}{\varepsilon + e - e\varepsilon}\rho_{h-1},\ h = 2, 3, ... \tag{26}$$

$$\rho_h = \rho_1 \frac{(1-\pi^h)}{1-\pi}\phi^{h-1},\ h = 2, 3, ... \tag{27}$$

Note that the effect on sales and variable inputs are proportional:

$$\Delta_h \ln S_{i,t+h} = \Delta_h \ln M_{i,t+h} = \Delta_h \ln L_{i,t+h}. \tag{28}$$

A firm's quasi-rent is defined as profits before capital costs, i.e.,

$$QR_{it} = S_{it} - w_t^m M_{it} - w_t^l L_{it}.$$

To estimate the change in quasi-rent in year $t + h$ caused by a one-time SKF subsidy in period t – it is assumed in both scenarios that $SKFS_{i,t+h} = 0$ for $h = 1, 2, ...$ – it is necessary to make a (counterfactual) prediction about what $QR_{i,t+h}$ would have been in the absence of SKF subsidies, i.e. we need a reference path for $QR_{i,t+h}$. A natural benchmark is the last observed quasi-rent, QR_{it}. Thus, because of the proportionality implied by (28), it follows that

$$\begin{aligned} QR_{i,t+h} &= e^{\lambda_h skfs_{it}} QR_{it} \\ &\simeq (1+\lambda_h skfs_{it}) QR_{it},\ \ h=1,2,... \end{aligned}$$

where we have used the 1. order approximation $e^x \simeq 1+x$. Similarly, relative to the initial capital stock, K_{it},

$$K_{i,t+h} \simeq (1+\rho_h skfs_{it}) K_{it},\ \ h=1,2,..\ .$$

Moreover, profits in year t can be defined as the quasi-rent less the rental cost of capital

$$\Pi_{it} = QR_{it} - q_K K_{i,t-1},$$

where q_K is the user price of capital – assumed constant forward in time for simplicity (cf. Section 4.3, footnote 7 and 8). The additional profits in $t+h$ due to the SKF subsidy $SKFS_{it}$ is therefore

$$\begin{aligned} \Delta_h \Pi_{i,t+h} &= \Delta_h QR_{i,t+h} - q_K \Delta_h K_{i,t+h-1} \\ &\simeq \begin{cases} \lambda_1 QR_{it} skfs_{it} & h=1 \\ \lambda_h QR_{it} skfs_{it} - \rho_{h-1} q_K K_{it} skfs_{it} & h=2,3,.., \end{cases} \end{aligned}$$

Aggregating over all the N firms in an industry, we define

$$\Delta_h \Pi_{t+h} = \sum_{i=1}^{N} \Delta_h \Pi_{i,t+h}.$$

The above expressions can be used to estimate the (private) rate of return on total SKF subsidy in an industry. The implicit rate of return on the total subsidy given to a particular industry can be found by finding the interest rate that makes the present value of the stream of "additional profits" $\{\Delta_h \Pi_{t+h}\}_{h=1}^{\infty}$ equal to the total subsidy, $SKFS_t = \sum_{i=1}^{N} SKFS_{it}$. The rate of return will thus depend on the initial distribution of the quasi-rent, QR_{it}, i.e., in the year the subsidy is given and the initial capital stock, K_{it}, in the population of firms who obtain SKF. The estimated return will reflect both the estimated effect of the SKF subsidy on the endogenous variables, and on the initial distribution of quasi-rent and capital in the firms who obtains SKF subsidy in that year.

Our results with regard to the estimated returns to the SKF subsidy in the different industries are presented in Table 8. The returns are quite stable across industries and over time, but are generally highest in 2004. The estimated returns in 2004 are in the range of 3-7 percent. The improvement in the rate of returns can be attributed to an improvement in business-cycle related conditions. Nevertheless, compared to the returns on alternative investment opportunities in the same period, such as stocks on the Oslo Stock Exchange, the returns to the SKF subsidy have been modest.

The above conclusions are, of course, very tentative, since the estimates of some key parameters, like τ, are uncertain. Moreover, many identifying restrictions have been made to arrive at the results regarding the private returns to SKF. First, the effect of the SKF subsidy is assumed to materialize one year after the subsidy is given and then gradually fade away when the lag length, h, increases, i.e. as ϕ^h goes to zero. However, this happens very slowly, since ϕ is close to one in all the industries. A more plausible assumption might be that there is a longer interval from the subsidy is given to the materialization of any effects. This suggests including longer lags of the $skfs$ variable in equation (21). However, given the data limitations, with only 3 years of SkatteFUNN that can be evaluated at present, such a model strategy is not yet feasible. Second, the effect of the SKF subsidy is assumed to be neutral in our analysis, since it is channeled through a Hicks-neutral efficiency factor, A_{it}. Instead, R&D subsidies might be labour augmenting, affecting e.g. the relation between the amount of man-hours worked by high- and low-skilled workers. In principle, our analysis might incorporate such effects through the labour augmenting variable β_{it}. However, our attempts to estimate models where innovations have both neutral and non-neutral consequences have so far not been very fruitful, as it led to even more imprecise parameter estimates.

Table 8: Estimated rate of return to the SKF subsidy in different industries

	Manufacturing				Services	
Year	NACE 15-24	NACE 25-29	NACE 30-33	NACE 34-36	NACE 72	NACE 74
2002	0.03	0.03	0.03	0.03	0.04	0.01
2003	0.03	0.03	0.03	0.06	0.03	0.01
2004	0.04	0.05	0.03	0.07	0.04	0.02

5 Conclusions

Norway is not a "big spender" when it comes to R&D expenditures. In particular, business spending on R&D is rather low by OECD standards. In 2002 the Norwegian government introduced a tax based incentive in order to stimulate business R&D in Norway. The system is a volume based tax credit system and is called SkatteFUNN. In 2002 the system only applied to SMEs but was extended to cover all firms from 2003 and onwards. In this paper, which is part of a comprehensive evaluation of SkatteFUNN, we analyse the effects on firm performance using data mainly for 2002-2004.

We base our study on econometric models of productivity effects of R&D spending. Some of these models are well known in the economic literature. The most standard model relates R&D spending to some measure of productivity, either labour productivity or total factor productivity. A number of specific assumptions need to be made in order to estimate the effects of R&D on productivity. In particular one must address whether or not to try to calculate the stock of R&D capital or simply to use R&D investments. We specify several model versions as an attempt to study the robustness of our results. The estimates of reduced form productivity equations give results that are generally in line with the results in the literature. R&D spending stimulates productivity growth at the firm level even after controlling for a number possible effects relating to industries, common shock etc. The effect of the tax credit is generally not significant in these models. The interpretation is that to the extent that SkatteFUNN increases R&D, its effect is captured by our R&D variables just like R&D spending in general (this is our null hypothesis). SkatteFUNN offers a subsidy for many marginal R&D projects and thus our alternative hypothesis was that the return on a tax financed project should on average be less than an ordinary R&D project. We find that the null hypothesis cannot be rejected in any of our models.

Using a more structural model of firm performance, where the R&D activity of the firm is incorporated into an unobservable productivity process that depends on the tax credit, we find that the tax credit has a positive but not very significant effect on productivity growth. Our preliminary results from this model indicate that the tax credit *does* lead to an increase in productivity, but that the rate of returns to the tax credit, considered as a marginal investment in these firms, is modest – about 4 per cent in 2004.

As a final comment at this stage we would like to emphasise that the tax credit

SkatteFUNN has only been operative since 2002. In our study we employ data for 2002-2004. This is a very short period for estimating effects of a fiscal incentive that aims at increasing R&D spending in the Norwegian business sector. Thus adding more years of observations will improve the amount of data and hopefully enable us to draw more solid conclusions.

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Appendix A: SkatteFUNN – background and design

SkatteFUNN (SKF) is aimed at increasing business expenditures on R&D in Norway. SKF is part of the Norwegian tax system. It was introduced in 2002 to small and medium sized enterprises (SME) but extended to all firms from 2003 and onwards. In the parliamentary discussion of the government white paper on the revised national budget in 2001, the majority in the Storting (parliament) asked the government to design and propose to the Storting a tax incentive to stimulate business R&D activities. The system should be in line with a proposal suggested by the majority of an expert committee put forward in 2000. The scheme was proposed as part of the tax law for 2002 and decided by the Storting in December 2001. The system was accepted by ESA in October 2002 and was thus in place for the tax year 2002. It was extended to cover all firms and not only SME's for the tax years 2003.

SKF is a system with tax credits implying 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 (NFR). If the tax credit exceeds the tax payable by the firm the difference is paid to the firm like a grant. If the firm is not in a tax position at all, the whole amount of the credit is paid to the firm as a negative tax or a grant. This payment is done when the tax authorities have completed their tax assessment, and takes place the year after the actual R&D expenses have occurred.

From 2003 the SKF scheme is as follows. For large firms (more than 250 employees, more than 40 million euros in turnover or a balance sheet of more than 27 million euros and is owned by more than 25 percent of a large enterprise) 18 percent of R&D expenses related to an approved project up to a limit of 4 million NOK (approximately 0.5 million euros). Thus for a large firm the maximum tax relief is 4*0.18=.72 million NOK (90 000 euros). If the firm has a project that involves collaboration with an approved research institute (according to a list decided upon by the Norwegian research council, NFR), it can also deduct expenses of a purchase of 4 million NOK in services from this institute so that the amount deductible becomes 1.44 million NOK (180 000 euros). For SME's the rate is 20 percent.

Since 2003 when SKF became available to all firms and not only SME's as in 2002, the number of projects has varied between 5 000 and 6 000. Since 2003 the revenue cost for the government has been roughly 1.3 billion NOK annually, of which nearly three quarters have been paid as grants. Around two thirds of the R&D expenses are personnel costs. Roughly 85 percent of all projects approved by NFR are undertaken by firms with less than 50 employees.

In 2004 13 percent of all manufacturing firms used SKF but only 1 percent in construction and most service sectors. Very few projects are designed as cooperation projects between firms or between firms and a research institute.

When the Storting (parliament) decided to introduce SKF it also included an evaluation of the scheme. This evaluation is carried out by Statistics Norway and includes the following aspects:

·SKF's ability to stimulate extra R&D effort and change firms' R&D behaviour

·SKF's effects on innovation and value creation in firms

·SKF's user friendliness

·SKF's administrative costs for users, tax authorities, NRF and other public bodies

·SKF's effect on R&D cooperation between firms and research institutes

·the relation between SKF and other R&D incentives

·SKF in an international context

·the quality of the SKF project and the extent of which they are tax motivated

Appendix B. Data sources

Accounts statistics: All joint-stock companies in Norway are obliged to publish company accounts every year. The accounts statistics contain information obtained from the income statements and balance sheets of joint-stock companies, in particular, the information about operating revenues, operating costs and operating result, labour costs, the book values of a firm's tangible fixed assets at the end of a year, their depreciation and write-downs. Currently, the most recent data are available for 2004.

The structural statistics: The term "structural statistics" is a general name for the different industrial activities statistics, such as Manufacturing statistics, Building and construction statistics, Wholesale and retail trade statistics, etc. They all have the same structure and include information about production, input factors and investments at the firm level. The structural statistic are organised according to the NACE standard and are based on General Trading Statements, which are given in an appendix to the tax return. In addition to some variables, which are common to those in the accounts statistics, the structural statistics contain data about purchases of tangible fixed assets and operational leasing. These data were matched with the data from the accounts statistics. As the firm identification number here and further we use the number given to the firm under registration in the Register of Enterprises, one of the Brønnøysund registers, which is operative from 1995.

R&D statistics: R&D statistics are the survey data collected by Statistics Norway every second year up to 2001 and annually later on. These data comprise detailed information about firm's R&D activities, in particular, about total R&D expenses with division into own-performed R&D and purchased R&D services, the number of employees engaged in R&D activities and the number of man-years worked in R&D. In each wave the sample is selected with a stratified method for firms with 10-50 employees, whereas the firms with more than 50 employees are all included. Strata are based on industry and firm size. Each survey contains about 5000 firms, although many of them do not provide complete information. Currently, the data are available for 1993, 1995, 1997, 1999, and 2001-2004.

The Tax Register: This register contains annual data obtained from the Norwegian Internal Revenue Service and provides information on paid taxes as well as different subsidies and deductions, received by a firm in a given year. In particular, we can get information on whether a firm has got a tax subsidy according to the SkatteFUNN ordering and what were the R&D expenses, which were the base for this subsidy.

The Register of Employers and Employees (REE): The REE contains information obtained from employers. All employers are obliged to send information to the REE about each individual employee's contract start and end, working hours, overtime and occupation. An exception is made only if a person works less than four hours per week in a given firm and/or was employed for less than six days. In addition, this register contains identification numbers for the firm and the employee, hence, the data can easily be aggregated to the firm level. These data are available for the period 1995–2004.

The National Education Database (NED): The NED gathers all individually based statistics on education from primary to tertiary education and has been provided by Statistics Norway since 1970. We use this data set to identify the length of education. For this purpose, we utilize the first digit of the NUS variable. This variable is constructed on the basis of the Norwegian Standard Classification of Education and is a six-digit number, the leading digit of which is the code of the educational level of the person. According to the Norwegian standard classification of education (NUS89), there are nine educational levels in addition to the major group for "unspecified length of education". The educational levels are given in Table 9. Currently, the most recent data are available for 2004.

Table 9: Educational levels

Tripartition of levels	Level	Class level
	0	Under school age
Primary education	1	1st – 6th
	2	7th – 9th
Secondary education	3	10th
	4	11th – 12th
	5	13th – 14th
Post-secondary education	6	15th – 16th
	7	17th – 18th
	8	19th+
	9	Unspecified

Appendix C: An approximate likelihood function

Let $y^*_{it,k} = \ln Y^*_{it,k}$. To derive the likelihood function in terms of the observed variables $y^*_{it,k}$, we note the following:

$$y_{it,k} = y^*_{it,k} + \ln(1 + \tau^y_k SKFS_{it} e^{-y^*_{it,k}}) \simeq y^*_{it,k} + \tau^y_k SKFS_{it} e^{-y^*_{it,k}}$$

The relation between the density function $f(y_{it,1}, ..., y_{it,4})$ of y_{it} and the density function $g(y^*_{it,1}, .., y^*_{it,4})$ of y^*_{it}, is given by the change of variables formula:

$$\begin{aligned} g(y^*_{it,1}, .., y^*_{it,4}) &= |\frac{\partial y_{it}}{\partial y^*_{it}}| f(y^*_{it,1} + \tau^y_S SKFS_{it} e^{-y^*_{it,1}}, y^*_{it,2} + \tau^y_M SKFS_{it} e^{-y^*_{it,2}}, y^*_{it,3} + \tau^y_L SKFS_{it} e^{-y^*_{it,3}}, y^*_{it,4}) \\ &\simeq \exp(-\tau^y_S SKFS_{it} e^{-y^*_{it,1}}) \exp(-\tau^y_M SKFS_{it} e^{-y^*_{it,2}}) \exp(-\tau^y_L SKFS_{it} e^{-y^*_{it,3}}) \times \\ &\quad f(y^*_{it,1} + \tau^y_S SKFS_{it} e^{-y^*_{it,2}}, y^*_{it,2} + \tau^y_M SKFS_{it} e^{-y^*_{it,2}}, y^*_{it,3} + \tau^y_L SKFS_{it} e^{-y^*_{it,3}}, y^*_{it,4}), \end{aligned}$$

where $\frac{\partial y_{it}}{\partial y^*_{it}}$ is the Jacobian of the transformation from y_{it} to y^*_{it}, and we have used the approximation $1 \pm \tau^y_k SKFS_{it} e^{-y^*_{it,k}} \simeq \exp(\pm \tau^y_k SKFS_{it} e^{-y^*_{it,k}})$. Thus, given that one can calculate an expression for the density function $f(\cdot)$ above, the change of variables formula just described gives an approximate likelihood in terms of the observed variables $y^*_{it,k}$.

Appendix D: Tables with descriptive statistics

Table 10: Overview of the firms represented in R&D statistics and Tax register in 2004

	R&D statistics											
Tax register	All	In	Not in	R&D	no R&D	<50	≥50	manuf	cons	retail	serv	others
All		4655		1600	3055	2852	1803	2077	493	430	553	1102
SKF firm	3284	950	2334	860	90	518	432	622	21	27	198	82
Not SKF		3705		740	2965	2334	1371	1455	472	403	355	1020
0-4	993	2	991	1	1	-	-	2				
5-9	540	7	533	7		-	-	6			1	
10-49	1034	509	525	465	44	-	-	300	5	14	148	42
≥50	717	432	285	387	45	-	-	314	16	13	49	40
manuf.	1221	622	599	555	67	308	314	-	-	-	-	-
constr.	99	21	78	18	3	5	16	-	-	-	-	-
retail trade	291	27	264	23	4	14	13	-	-	-	-	-
services	1266	198	1068	190	8	149	49	-	-	-	-	-
others	407	82	325	74	8	42	40	-	-	-	-	-

Table 11: R&D investment, R&D stock and SKF stock. Mean (standard deviation)

	2001	2002	2003	2004	2001-2004
Number of observations	783	783	783	783	3132
R&D intensity	0.08(0.242)	0.082(0.227)	0.092(0.213)	0.077(0.185)	0.083(0.218)
R&Dcap. to labour ratio	0.123(0.328)	0.113(0.286)	0.114(0.285)	0.118(0.287)	0.117(0.297)
h	22.3 %	22.5 %	23.0 %	23.3 %	22 %
Share of obs. $(R\&D > 0)$	46.6 %	49.9 %	59.8 %	59.0 %	53.8 %
R&D intensity $\mid R\&D > 0$	0.171(0.332)	0.166(0.299)	0.154(0.258)	0.13(0.226)	0.154(0.278)
R&Dcap/labour $\mid R\&D > 0$	0.244(0.448)	0.215(0.376)	0.187(0.349)	0.194(0.352)	0.208(0.38)
$h \mid R\&D > 0$	27.7 %	27.3 %	25.7 %	26.3 %	26.7 %
Share of obs. $(R\&D\_av > 0)$	74.2 %	74.2 %	74.2 %	74.2 %	74.2 %
R&D intensity $\mid R\&D\_av > 0$	0.108(0.276)	0.112(0.257)	0.124(0.24)	0.103(0.208)	0.112(0.246)
R&Dcap/labour$\mid R\&D_av > 0$	0.165(0.371)	0.152(0.322)	0.154(0.321)	0.159(0.323)	0.158(0.335)
$h \mid R\&D\_average > 0$	24.2 %	24.4 %	24.7 %	25.1 %	24.6 %
Share of obs. $(d\_SKF > 0)$	0 %	10.6 %	34.6 %	34.7 %	
$skf_{t-1} \mid d\_SKF > 0$	0	0	0.004(0.018)	0.012(0.032)	

Table 12: Manufacturing: Total number of firms

	NACE 15-24		NACE 25-29		NACE 30-33		NACE 34-36	
Year	All	SKF	All	SKF	All	SKF	All	SKF
1995	3365	-	2224	-	444	-	896	-
1996	3479	-	2299	-	494	-	928	-
1997	3583	-	2387	-	515	-	993	-
1998	3644	-	2456	-	530	-	1008	-
1999	3567	-	2449	-	526	-	1034	-
2000	3596	-	2483	-	528	-	1047	-
2001	3588	-	2493	-	553	-	1061	-
2002	3581	109	2565	199	558	89	1062	70
2003	3462	309	2533	364	560	147	1043	152
2004	3172	319	2349	349	505	128	961	154

Table 13: Services: Total number of firms

	NACE 72		NACE 74	
Year	All	SKF	All	SKF
1995	581		3850	
1996	764		4427	
1997	940		4694	
1998	1263		5175	
1999	1510		5269	
2000	1764		5841	
2001	1882		6037	
2002	1941	268	6264	196
2003	1969	415	6357	326
2004	1714	348	5824	308

Table 14: SKF subsidy in mill NOK, fixed 1993 prices

	Manufacturing				Services	
Year	NACE 15-24	NACE 25-29	NACE 30-33	NACE 34-36	NACE 72	NACE 74
2002	35	50	38	18	105	115
2003	101	101	64	49	154	172
2004	93	98	56	46	136	152

Table 15: Mean SKF subsidy as share of wage costs among firms with positive subsidy

	Manufacturing				Services	
Year	NACE 15-24	NACE 25-29	NACE 30-33	NACE 34-36	NACE 72	NACE 74
2002	0.14	0.07	0.16	0.06	0.40	0.40
2003	0.08	0.09	0.13	0.09	0.27	0.25
2004	0.07	0.06	0.12	0.09	0.23	0.22