

Access to Research and Technical Information in Denmark

Innovation: Analyse og evaluering 20/2011



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A knowledge economy has been described as one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activities (Department of Trade and Industry 1998).

Small and medium sized enterprises (SMEs) form a major part of many economies and they play a key role in innovation. Consequently, SME access to and use of research findings is important, not only for firm-level performance but also for the overall performance of national economies.

The aim of this study is to examine levels of access to and use of research and technical information by knowledge-based SMEs in Denmark. We explore current levels of access and use, whether there are any barriers to access, access difficulties or gaps, and the costs and benefits involved in accessing research findings.

The sample

Research for this study involved an online survey and in-depth interviews. The sample is neither large nor is it a random statistical sampling, and should not be interpreted as representative of SMEs in general or even of knowledge-based SMEs. Rather, it is an attempt to better understand the information access needs and concerns of a category of enterprises of interest to the Danish Agency for Science, Technology and Innovation (FI) and Denmark's Electronic Research Library (DEFF). In view of this, no attempt is made at statistical analysis. We simply report responses as a percentage of total respondents/responses, the number of which ('N') is report for each question.

The survey generated 98 usable responses, and 23 interviews were conducted. Of course, sample size is contextual and Denmark is a relatively small country. Nevertheless, the interview and questionnaire responses we obtained are similar to those reported in a number of previous studies around the world, suggesting that our findings are reasonably robust.

The survey

The firms we surveyed were small (49% had fewer than ten employees). Average sales revenue was DKK 130 million (EUR 17 million) per year and average annual R&D expenditure DKK 5.7 million (EUR 765 000). One-third were incubator firms, with relatively high research intensity (10% of sales revenue). **The respondents were mainly in research or senior management roles.**

Information access

Research articles, patent information, scientific and technical standards, technical and market information were seen as the **most important information sources**. Forty-eight per cent rated research articles as very or extremely important, and among those in research roles a higher 64% did so.

More than two-thirds reported **having difficulties accessing** market survey research and reports and Doctoral or Masters theses, 62% reported difficulties accessing technical reports from government agencies and 55% reported difficulties accessing research articles. Comparing responses on importance and ease of access, suggests that research articles and market survey research and reports are seen to be both important and difficult to access.

Respondents **wanted improved access** to research articles, market surveys and reports, patent information and scientific and technical standards. Fifty-nine per cent of researchers wanted improved access to research articles, as did 47% of all respondents.

The most **widely used means of access to toll access materials** are personal subscriptions and in-house library or information services. Public libraries, inter-library loans and pay-per-view (PPV) are little used. Sixty-two per cent reported using personal subscriptions monthly or more frequently, and 57% an in-house library. Many others rely on their links to universities and colleagues for their access.

Use of Open Access materials is widespread. More than 50% used free institutional or subject repositories and Open Access journals monthly or more regularly, and among researchers 72% reported using free institutional or subject repositories and 56% Open Access journals monthly or more regularly.

Sixty-eight per cent reported **reading or consulting research articles** monthly or more regularly. Among researchers the use of research articles was even more regular, with 85% reporting reading or consulting research articles monthly or more regularly, 59% weekly or more regularly and 15% daily.

Thirty-eight per cent said they always or frequently had **difficulty accessing research articles** and a further 41% said they sometimes had difficulties. Among researchers, a higher 41% said they always or frequently had difficulty accessing research articles and a further 41% sometimes had difficulties. Just 6% said that they never experienced access difficulties.

Costs and benefits

Both access and access difficulties involve costs. The average time spent trying to access the last research article they had difficulty accessing was 51 minutes. Among researchers, the average time was 63 minutes. If around 60 minutes were characteristic for researchers, then in the current environment the time spent dealing with research article access difficulties might be costing around DKK 540 million (EUR 72 million) per year among specialist researchers in Denmark alone.

Access to academic research brings substantial benefits for firms. Twenty-seven per cent of the products and 19% of the processes developed or introduced during the last three years would have been delayed or abandoned without access to academic research. These new products contribute an average 46% of annual sales. Hence, the value of academic research to sales was equivalent to DKK 16 million (EUR 2.1 million) per firm per year, and the average value of cost savings was DKK 490 000 per firm per year.

Access barriers and delays involve costs. It would have taken an average of 2.2 years longer to develop or introduce the new products or processes in the absence of contributing academic research. For new products, a 2.2 years delay would cost around DKK 36 million (EUR 4.8 million) per firm in lost sales, and for new processes it would cost around DKK 211 000 per firm.

The interviews

Firms see research articles and patent information as the most important sources of information; some also mentioned scientific and technical standards and market information.

Accessibility issues were divided between: (i) reports of relatively easy access, but **concerns over affordability**; and (ii) reports of **access difficulties** and the workarounds they use to gain access. Comments included:

- We need scientific papers from not just one application area, but from many – some basic science areas and some specialised ones. We cannot subscribe, because there are too many journals that the papers come from.
- At least 75% of the research articles needed in the last 12 months have been difficult to access. The difficulty is accessing the full-text.
- Market survey research is fairly difficult, and there is quite a cost to accessing this information as well.

Workarounds included:

- If an article is needed, we use the nearest university library, but this is an hour's drive away and we cannot have online access. We can pay for articles from publishers' websites, and sometimes do, but this is an expensive option for small companies.
- Locating and accessing the abstract [of research articles] is not difficult, but accessing the full-text involves a cost. The company does not pay to view articles... it is simply too expensive. Our workaround is to obtain articles through colleagues and friends who work in universities and research institutes.

When asked to what they would like to have improved access, the same priorities and issues arose – with **calls for improved access to research articles, patent, legislative/regulatory and market information, and discussion of the key issue of affordability**, especially for small start-up firms with highly constrained budgets. Comments included:

- If access to any of these types of information could be improved it would *definitely* be to research articles. Access to these is “a really, really major problem... The core business of the company is based on this kind of knowledge, but access to scientific information is so difficult”.

- If access could be improved to any of these, it would be to patents. This is solely because of the cost. Finding patents is not too difficult, but getting access to them is expensive.

Firms realise the importance and value of access to research and technical information. The following stories emerged:

- One example of the impact of not having access to the right information was very costly for the company. The company had used a particular type of 'x' which had undergone a ten-year test/assessment. When the results came out they showed that the material was not suitable. The company missed this and used the 'x' product in their work, and had a lot of subsequent problems with insurance, etc. It was very expensive.
- The company experienced one instance where lack of access was quite expensive. The company had to do the research itself because the published article reporting the original research was inaccessible... It took several months and thus had a cost in terms of effort and lost time.
- Access problems have caused a delay in product development that was almost catastrophic. We took out a patent, which ran into problems that could have been addressed had we had access to one particular scientific paper while drawing up the patent information. We did not, so filed the patent application without this additional information. As a result, the patent was delayed while we had to go back and include certain things that emanated from that article. In the meantime, new investors, who we had lined up, would not come on board until the patent was successfully filed. There was a two-month hold-up, and we only filed the patent just within the investors' deadline for signing up with the company. It would otherwise have failed through lack of investment.

An important point made by interviewees is that the subscription model does not work for them because **the content they need is spread widely across many titles**. The world they operate in is not organised into disciplines and their access needs span a wide range of basic and applied research across disciplinary boundaries. The pay-per-view model can provide access to particular articles, at a cost. But **many small firms find the cost too high**. However, the pay-per-view model cannot provide the breadth of access to the literature necessary for them to scan widely and be aware of what of relevance is available, and subscription to mainstream abstracting and indexing services is too expensive for small firms.

What is needed is sufficient breadth of access for them to be able to scan widely and be aware of developments and access to specific content. Effectively, the value of access has both specific and network dimensions. Hence, neither of the mainstream toll access publishing models entirely meets their needs.

Options for improving access

Options for improving access include: (i) **addressing information literacy** limitations and improving the capacity of SMEs to navigate the information landscape; (ii) **addressing accessibility and affordability** of access for SMEs; and (iii) responding to the expressed concerns and wishes.

Information literacy

It is clear that SMEs sometimes lack the higher-level information literacy skills that would help them to more effectively navigate the information landscape, discover and access the information they need.

That generic search engines (*e.g.* Google) are so overwhelmingly used for search, discovery and access, and the second most commonly cited difficulty encountered is “I searched for the article online, but could not find the article” suggests that there may be scope to further develop information literacy skills and/or provide support.

Information sharing and raising awareness and skills through meetings, workshops and training sessions might provide one useful avenue for **developing information literacy skills**, but those operating in SMEs are often highly time-constrained. Another option might be to offer a **targeted ‘reference librarian’ service** that could provide a one-stop-shop point of contact to provide advice and support for knowledge-based SMEs.

Accessibility and affordability

This and other studies reveal the focus of SME information access needs and the areas in which they experience most difficulties. There is a need for improved access to research articles, patent, legislative/regulatory and market information. And it is clear that **the issue is one of both accessibility and affordability**.

Addressing affordability rests on reducing the direct monetary and time penalty costs involved in accessing the information needed. This could be through a range of options, including:

- **Consortial purchasing** – exploring the possibility of a national or possibly regional Scandinavian purchasing and licensing scheme;
- **Extended licensing** – exploring the possibility of extending existing university and other consortial purchasing and licensing to more easily include SME access through research libraries;
- **Specific funding** – exploring the possibility of establishing a funding program to support SME access; and
- **Supporting Open Access** – by encouraging and, perhaps, mandating Open Access to publicly funded research findings in the form of both research articles and other publications and scientific and research data; and encouraging others around to world to do likewise.

However, these options carry very different costs for government and others. For example, the first three would require a centralisation of funding and/or additional funding, whereas the last is free to government, researchers and other SME users.

For research articles, patent and other information, SMEs need sufficient breadth of access for them to be able to scan widely and be aware of developments as well as access to specific content. The widespread use of Open Access alternatives appears to be a natural response.

An SME wish list

A number of interviewees and survey respondents made specific requests and suggestions, so we leave the last word to them.

- It is essential to have access to scientific information if you are a small research-based company. If not, we could not do what we do and would have to give up to much larger competitors. **The research libraries are so important.**
- Patents are very easy. We use professionals, but they are expensive. **We would love to know about free sources for this information.**
- Legislative and regulatory information is very important, and **it is important that this information is provided in forms that are easily understood and used by small firms** who do not have the experts that large companies have to help them understand the implications of regulatory information.
- For me, if the Ministry could do something it would be to **provide some type of access to a number of free articles or an easier, cheaper, way of doing it** than how I can do it today, because paying for accessing all these articles today is very expensive.
- **Open access would be a big help.** An open database of literature would be a great thing and the user interface should be as easy and intuitive as possible... That would be very helpful.

En videnøkonomi er blevet beskrevet som en økonomi, hvor opbygning og udnyttelse af viden har fået afgørende betydning for, at der skabes vækst. Det drejer sig ikke bare om at flytte grænserne for viden, men også om at sikre en mere effektiv anvendelse og udnyttelse af alle former for viden inden for alle økonomiske aktiviteter (Department of Trade and Industry 1998).

Små og mellemstore virksomheder udgør ofte en væsentlig del af økonomien og har stor betydning for innovation. Det er derfor vigtigt, at de har adgang til og gør brug af forskningsresultater – ikke bare for, hvordan virksomhederne klarer sig, men også for, hvordan de nationale økonomier klarer sig.

Formålet med denne undersøgelse er at klarlægge, i hvilket omfang videnbase-rede små og mellemstore virksomheder i Danmark har adgang til og anvender forskningsmæssig og teknisk information. Vi undersøger den aktuelle situation med hensyn til adgang og anvendelse, hvorvidt der er barrierer for adgangen, adgangsproblemer eller utilstrækkelig adgang, og hvilke omkostninger og fordele der er forbundet med at få adgang til forskningsresultater.

Undersøgelsen

De undersøgte firmaer var små (49% af dem havde under ti ansatte). Salgsindtægterne lå i gennemsnit på 130 mio. DKK (17 mio. EUR) pr. år, og de årlige F&U-omkostninger lå i gennemsnit på 5,7 mio. DKK (765.000 EUR). En tredjedel af dem var innovative iværksætterfirmaer med en forholdsvis høj forskningsintensitet (10% af salgsindtægterne). **De fleste af respondenterne beskæftigede sig med forskning eller ledelse.**

Adgang til information

Forskningsartikler, patentinformation, videnskabelige og tekniske standarder, teknisk information og markedsinformation blev betragtet som de **vigtigste informationskilder**. 48% anså forskningsartikler for at være meget eller ekstremt vigtige. Blandt forskerne var 64% af den samme mening.

Mere end to tredjedele angav, at de har vanskeligt ved at få adgang til markedsundersøgelser, rapporter, specialeopgaver eller afhandlinger, 62% angav, at de har **vanskeligt ved at få adgang** til tekniske rapporter fra statslige instanser, og 55% angav, at de har vanskeligt ved at få adgang til forskningsartikler. Hvis man sammenligner svarene om vigtigheden og tilgængeligheden af den pågældende information, ser det ud til, at forskningsartikler og markedsundersøgelser og -rapporter både opfattes som vigtige og vanskelige at få adgang til.

Respondenterne **ønskede bedre adgang** til forskningsartikler, markedsundersøgelser og -rapporter, patentinformation og videnskabelige og tekniske standarder. 59% af forskerne ønskede bedre adgang til forskningsartikler mod 47% af samtlige respondenter.

Adgang til toll access-materiale (hvor der betales for materialet) fås typisk via personlige abonnementer og firmaets eget bibliotek eller informationstjenester.

Offentlige biblioteker, lån fra andre biblioteker og pay-per-view (betaling for det enkelte dokument) benyttes ikke særlig tit. 62% oplyste, at de gør brug af personlige abonnementer hver måned eller oftere, og 57% benytter firmaets eget bibliotek. Mange andre får adgang via universiteter, som de er tilknyttet, og kolleger.

Open access-materiale (frit tilgængeligt materiale) anvendes ofte. Over 50% anvender gratis institutionelle arkiver eller emnearkiver og open access-tidsskrifter hver måned eller oftere. Blandt forskerne angav 72%, at de anvender gratis institutionelle arkiver eller emnearkiver, og 56%, at de anvender open access-tidsskrifter, hver måned eller oftere.

68% angav, at de **læser eller tjekker forskningsartikler** hver måned eller oftere. Forskerne er de mest flittige brugere af forskningsartikler. 85% angav, at de læser eller tjekker forskningsartikler hver måned eller oftere, 59% gør det hver uge eller oftere, og 15% gør det dagligt.

38% udtalte, at de altid eller tit har **svært ved at få fat i forskningsartikler**, og 41% udtalte, at de ind imellem har svært ved det. Blandt forskerne var tallene højere. 41% udtalte, at de altid eller tit har svært ved at få fat i forskningsartikler, og 41% udtalte, at de ind imellem har svært ved det. Kun 6% udtalte, at de aldrig har haft svært ved at få adgang.

Omkostninger og fordele

Både adgang og adgangsproblemer koster penge. Respondenterne brugte i gennemsnit 51 minutter på at få adgang til den forskningsartikel, som de senest havde svært ved at få adgang til. Forskerne brugte i gennemsnit 63 minutter på det. Hvis det antages, at forskere typisk bruger ca. 60 minutter på at få adgang, betyder det, at problemer med at få adgang til forskningsartikler under de nuværende forhold kan løbe op i ca. 540 mio. DKK (72 mio. EUR) om året alene blandt specialiserede forskere i Danmark.

Adgang til akademisk forskning er til stor fordel for firmaerne. 27% af de produkter og 19% af de processer, der blev udviklet eller introduceret i løbet af de seneste tre år, ville være blevet forsinket eller opgivet, hvis der ikke havde været adgang til akademisk forskning. De nye produkter bidrager i gennemsnit med 46% til den årlige omsætning. Den akademiske forsknings omsætningsmæssige værdi svarede således til 16 mio. DKK (2,1 mio. EUR) pr. firma pr. år, og den gennemsnitlige omkostningsbesparelse udgjorde 490.000 DKK pr. firma pr. år.

Adgangsbarrierer og forsinkelser koster penge. Det ville i gennemsnit have taget 2,2 år længere at udvikle eller introducere de nye produkter eller processer uden brug af den akademiske forskning. For nye produkter vil en forsinkelse på 2,2 år medføre, at firmaet mister ca. 36 mio. DKK (4,8 mio. EUR) i omsætning, og for nye processer vil det medføre, at firmaet mister ca. 211.000 DKK.

Interviewene

Firmaerne betragter forskningsartikler og patentinformation som de vigtigste informationskilder. Nogle pegede også på videnskabelige og tekniske standarder og markedsinformation.

Der var delte meninger om tilgængeligheden: *i)* nogle mente, at det var forholdsvis let at få adgang, men var **utilfredse med prisniveauet**, og *ii)* andre fortalte, at de havde **problemer med at få adgang** og var nødt til at gøre det ad omveje. Der blev bl.a. fremsat følgende bemærkninger:

- Vi har brug for videnskabelige artikler fra ikke bare ét, men mange anvendelsesområder – både grundlæggende videnskabelige områder og mere specialiserede områder. Det er ikke muligt for os at abonnere, fordi artiklerne findes i for mange forskellige tidsskrifter.
- Mindst 75% af de forskningsartikler, vi havde brug for i løbet af de seneste 12 måneder, var været svære at få fat i. Problemet er at få adgang til artiklerne i fuldtekst.
- Markedsundersøgelser er ret komplicerede, og det koster også ret meget at få adgang til disse oplysninger.

Firmaerne benytter sig bl.a. af følgende omveje:

- Når vi har brug for en artikel, benytter vi det nærmeste universitetsbibliotek, men det er en times kørsel herfra, og vi kan ikke få onlineadgang. Vi kan betale for at hente artikler fra forlagenes websteder og gør det af og til, men det er dyrt for små virksomheder.
- Det er ikke svært at finde og få adgang til resuméer [af forskningsartikler], men der skal betales for at få adgang til selve artiklen. Virksomheden betaler ikke for at få artikler at se ... det er simpelthen for dyrt. Vi gør tit det, at vi får fat i artiklerne via kolleger og venner, der er ansat på universiteter og forskningsinstitutter.

Adspurgte om, hvordan adgangen bør forbedres, var de interviewede personer enige om, hvilke problemer der skal tages op, og hvordan de skal prioriteres – der er **brug for bedre adgang til forskningsartikler, patentinformation, love og administrative bestemmelser og markedsinformation, og det er vigtigt at se på omkostningsproblemet**, især for små nystartede firmaer med meget begrænsede budgetter. Der blev bl.a. fremsat følgende bemærkninger:

- Hvis man kan forbedre adgangen til disse typer information, er det *helt klart* forskningsartiklerne, der bør fokuseres på. Adgangen til disse artikler udgør ”et meget stort problem ... Virksomhedens kerneaktiviteter bygger på denne form for viden, men det er rigtig svært at få adgang til videnskabelig information”.
- Hvis adgangen til disse informationskilder kan forbedres, er det patenter, der bør fokuseres på. Det skyldes udelukkende omkostningerne. Det er ikke svært at finde patenterne, men dyrt at få adgang til dem.

Firmaerne er opmærksomme på vigtigheden og værdien af adgang til forskningsmæssig og teknisk information. De fortalte om følgende erfaringer:

- Virksomheden har engang mistet mange penge, fordi den ikke var i besiddelse af de rigtige oplysninger. Virksomheden havde brugt en særlig form for ”x”, der

var blevet afprøvet/vurderet i en periode på ti år. Da resultaterne blev fremlagt, viste de, at materialet ikke var egnet. Virksomheden var ikke opmærksom på det og brugte ”x”-produktet i forbindelse med sit arbejde, hvilket var skyld i mange efterfølgende problemer med forsikringen osv. Det var meget dyrt.

- Virksomheden har i ét tilfælde mistet mange penge på grund af manglende adgang. Virksomheden var nødt til at udføre sin egen forskning, fordi den ikke kunne få adgang til den artikel, hvori den oprindelige forskning var beskrevet ... Det tog mange måneder og var derfor meget dyrt såvel arbejds- som tidsmæssigt.
- Adgangsproblemer har været skyld i en forsinkelse af produktudviklingen, der næsten blev katastrofal. Vi udtog et patent, som medførte problemer, der kunne have været undgået, hvis vi havde haft adgang til et bestemt videnskabeligt dokument, da vi formulerede den pågældende patentinformation. Vi havde ikke dokumentet og indgav patentansøgningen uden den supplerende information. Resultatet var, at det tog længere tid at få udstedt patentet, og at vi var nødt til at gå tilbage og indarbejde elementer fra den pågældende artikel. De nye investorer, vi havde fundet, ville ikke forpligte sig, før der var givet grønt lys for patentet. Der opstod en forsinkelse på to måneder, og vi nåede kun lige at registrere patentet, før investorernes frist for at indgå en aftale med virksomheden udløb. Uden investeringerne ville vi ikke være kommet videre.

De interviewede har gjort opmærksom på et vigtigt punkt, nemlig at abonnementsmodellen ikke dur for dem, fordi **det indhold, de har brug for, er spredt på mange forskellige titler**. De arbejder i et miljø, der ikke er fagligt orienteret, og er nødt til at have adgang til mange former for grundforskning og anvendt forskning på tværs af faggrænserne. Pay-per-view-modellen giver adgang til specifikke artikler mod betaling. Men **mange små firmaer synes, at prisen er for høj**. Pay-per-view-modellen vil imidlertid ikke kunne sikre den brede adgang til litteratur, som de behøver for at kunne søge bredt og finde ud af, hvad der findes af relevant materiale, og det er for dyrt for små virksomheder at abonnere på almindelige abstract- og indekseringstjenester.

Det, de har brug for, er en tilstrækkelig bred adgang, således at de søge bredt, følge med i, hvad der sker, og få adgang til specifikt indhold. Værdien af at have adgang har i realiteten både en specifik dimension og en netværksdimension. De mest almindelige toll access-modeller opfylder derfor ikke virksomhedernes behov fuldt ud.

Måder at forbedre adgangen på

Adgangen kan forbedres på følgende måder: *i)* ved at **rette op på utilstrækkelig informationskompetence** og forbedre små og mellemstore virksomheders evne til at færdes i informationslandskabet, *ii)* ved at **sikre en lettere og billigere adgang** for små og mellemstore virksomheder og *iii)* ved at tage hensyn til de bekymringer og ønsker, der er kommet til udtryk.

Informationskompetence

Det er tydeligt, at små og mellemstore virksomheder undertiden ikke har tilstrækkelige informationskompetencer til at kunne færdes mere effektivt i informationslandskabet, finde de oplysninger, de har brug for, og få adgang til dem.

De generelle søgemaskiner (*f.eks.* Google) anvendes i meget stor udstrækning til at søge, finde og få adgang til oplysninger, og det problem, der nævnes næsthyppigst – ”jeg søgte efter artiklen på nettet, men fandt den ikke” – tyder på, at det kan være hensigtsmæssigt at forbedre informationskompetencerne yderligere og/eller yde støtte.

Udveksling af oplysning og forbedring af viden og færdigheder ved hjælp af møder, workshopper og kurser kan være en god måde at **udvikle informationskompetencerne** på, men ansatte i små og mellemstore virksomheder er ofte underlagt et stort tidspres. En anden mulighed kunne være at tilbyde **en målrettet ”referencebibliotekar-tjeneste”** i form af et centralt kontaktpunkt, hvor videnbaserede smv’er kan få rådgivning og hjælp.

Lettere og billigere adgang

Denne og andre undersøgelser afslører, hvor små og mellemstore virksomheder har brug for adgang til information, og på hvilke områder de støder på flest vanskeligheder. Der er brug for en bedre adgang til forskningsartikler, patenter, love og administrative bestemmelser samt markedsinformation. Og det er klart, at det **både handler om at gøre det lettere og billigere at få adgang.**

Adgangen vil blive billigere, hvis de direkte omkostninger og den tid, der går med at få adgang til information, reduceres. Det kan gøres på flere måder, bl.a. ved hjælp af:

- **fælles indkøbsordninger** – man kan undersøge, om det vil være muligt at indføre en national eller eventuelt regional indkøbs- og licensordning efter skandinavisk forbillede
- **udvidede licensordninger** – man kan undersøge, om det vil være muligt at udvide universiteternes og andre fælles indkøbs- og licensordninger for at gøre det nemmere for små og mellemstore virksomheder at få adgang via forskningsbiblioteker
- **specifik støtte** – man kan undersøge, om det vil være muligt at indføre et støtteprogram for at hjælpe små og mellemstore virksomheder med at få adgang, og
- **støtte til open access** – man kan opfordre til og måske også tillade, at resultater af offentligt finansierede forskning i form af forskningsartikler, andre publikationer samt videnskabelige og forskningsmæssige data gøres frit tilgængelige, og opfordre andre til at gøre det samme rundt om i verden.

Disse muligheder er dog forbundet med meget forskellige omkostninger for myndighederne og andre. De første tre muligheder vil eksempelvis kræve en centralisering af støtten og/eller den supplerende støtte, hvorimod den sidste er gratis for myndighederne, forskerne og andre små og mellemstore virksomheder.

Hvad angår forskningsartikler, patentinformation og andre oplysninger har små og mellemstore virksomheder brug for en tilstrækkelig bred adgang, således at de kan søge bredt, følge med i, hvad der sker, og få adgang til specifikt indhold. Den mest nærliggende løsning vil være at udbrede anvendelsen af frit tilgængelige informationskilder.

Små og mellemstore virksomheders ønskeliste

En række af de personer, der blev interviewet og deltog i undersøgelsen, kom med specifikke anmodninger og forslag. De får derfor det sidste ord.

- En lille forskningsbaseret virksomhed er afhængig af at have adgang til videnskabelig information. Uden den information ville vi ikke kunne gøre det, vi gør, og være nødt til at give op over for større konkurrenter. **Forskningsbibliotekerne spiller en meget vigtig rolle.**
- Patenter er meget lette at få fat i. Vi gør brug af eksterne rådgivere, men det er dyrt. **Vi vil meget gerne have at vide, hvor vi kan finde denne information gratis.**
- Oplysninger om love og administrative bestemmelser er meget vigtige, og **det er vigtigt, at oplysningerne leveres på en sådan måde, at de er lette at forstå og anvende af små firmaer**, som til forskel fra store virksomheder ikke råder over eksperter, der kan hjælpe dem med at forstå, hvad de lovmæssige oplysninger indebærer.
- Hvis ministeriet skal gøre noget, mener jeg, det bør være at **sørge for, at der på en eller anden måde gives adgang til gratis artikler, eller at gøre det lettere og billigere at få adgang**, end det er tilfældet i dag, hvor det koster mange penge at få adgang til alle disse artikler.
- **Open access vil være til stor hjælp.** Det kunne være rigtig godt at have en gratis litteraturlatabase, og brugerfladen skal være så let og intuitiv som muligt ... Det ville være en stor hjælp.

A knowledge economy has been described as one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activities (Department of Trade and Industry 1998).

Small and medium sized enterprises (SMEs) form a major part of many economies and while definitions vary between countries,¹ they account for around two-thirds of all private sector employment in Europe. In 2008, no less than 97% of all businesses in Denmark had fewer than 50 employees and just 1% had 100 or more employees. Reflecting the dominance of micro-enterprises in Denmark, 82% had fewer than 10 employees and no less than 46% had just one employee.

SMEs play a key role in innovation, but because of their size they are less able to rely on internal research for their ideas and innovation. Consequently, SME access to and use of research findings is important, not only for firm-level performance but also for the overall performance of national economies – particularly for economies with a large share of SMEs.

Aims of this study

The aim of this study is to examine levels of access to and use of research and technical information by knowledge-based SMEs in Denmark. We explore current levels of access and use, whether there are any barriers to access, access difficulties or gaps, and the costs and benefits involved in accessing research findings.

We explore access to a wide range of research and technical information, but the focus is on *research articles* representing the findings of academic and public sector research. We seek to explore the levels of access to and use of such materials, how important research articles are as a source of information and for the innovative performance of firms, and whether there are any access difficulties that might be limiting access and the realisation of maximum returns to public investment in research.

Hence, this study builds on previous access studies (*e.g.* Swan 2008 and Ware 2009) and on work focusing on the potential economic impacts of more Open Access to research (*e.g.* Houghton 2009, 2009a; Houghton *et al.* 2009, 2009a and 2010).

The economic impacts of research

There have been many studies exploring the economic impacts of R&D at the firm, industry and national levels, with the former exploring private returns and the latter social returns (Bernstein and Nadiri 1991; Griliches 1995; Industry Commission 1995; Salter and Martin 2001; Scott *et al.* 2002; Dowrick 2003; Shanks and Zheng 2006; Martin and Tang 2007; Sveikauskas 2007; Hall *et al.* 2009). A characteristic finding is that returns to R&D are high. Dowrick (2003, p16) noted that:

¹ In the European Union, small businesses are defined as having fewer than 50 employees and medium sized business as those with 50 to 249 employees. Small businesses may not have a turnover of more than EUR 50 million per annum.

“Estimates of private returns to firms’ own investment in R&D still produce varying figures, but there is an emerging consensus that gross returns in the range between 20% and 30% are both common and plausible. Taking account of risk-premia required to finance commercial R&D and taking account of depreciation rates on R&D capital, the net private return on R&D investment appears to be broadly comparable with the return on investment in physical capital.

Microeconomic studies confirm the existence of significant spillovers of knowledge from the firms that perform the R&D to other firms and industries. Taking account of measured spillovers typically raises the estimated gross rate of return on business investment into the range between 30% and 40%. But authors warn that these are likely to be underestimates of the true social rate of return because the micro-economic studies do not usually cover all of the sectors of the economy.

Macroeconomic studies, which by definition cover all sectors of the economy, do indeed find significantly higher returns to R&D in OECD countries, with estimates ranging from 50% to over 100%. Macroeconomic studies that distinguish between public and private sector R&D and allow for longer lags for the latter to affect productivity, find that public sector R&D contributes significantly to productivity, albeit less strongly than private sector R&D.”

Looking specifically at the impacts of **publicly funded research**, Martin and Tang (2007, pp6-7) noted that:

...there have been numerous attempts to measure the economic impact of publicly funded research and development (R&D), all of which show a large positive contribution to economic growth. For instance, the studies cited in OTA (1986) and Griliches (1995) spanning over 30 years of work find a rate of return to public R&D of between 20 and 50%... Mansfield (1991)... estimated the rate of [private] return for academic research to be 28%... [and] Toole (1999) has shown... that firms appropriate a [private] return on public science investment of between 12% and 41%.

Arundel and Geuna (2003, p3) surveyed the literature, and reported that estimates of the rate of return to publicly funded research ranged between 20% and 60%.

Mansfield (1991) attempted to measure the returns to R&D for those innovations that are directly related to **academic research**. From a survey of R&D executives in US firms, he found that around 10% of new products and processes would not have occurred (without a substantial delay, of one year or more) in the absence of recent academic research, and that these contributed around 3% of total sales and 1% of total costs. In a follow-up study, Mansfield (1998) found that academic research was increasingly important for industrial innovation, contributing to more than 5% of sales and 2% of costs. Beisea and Stahla (1998) repeated Mansfield’s study in Germany, with similar results. Around one-tenth of innovations relied on public research and they accounted for around 5% of new product sales.

Box 1 Diffusion of knowledge and returns to R&D

To illustrate the importance of the diffusion of knowledge from firms undertaking research to the broader community, consider technical change in pharmaceuticals. Statins are a new class of anti-cholesterol drugs which have contributed greatly to the decline of heart disease. A major pharmaceutical firm introduced the first commercial statin product in 1987, and conducted pioneering research demonstrating that statins were safe, lowered cholesterol, and successfully reduced the death rate from heart disease. Since 1987, several firms have introduced new and improved statins. A different firm now produces a new and greatly improved statin, which lowers cholesterol more effectively, and has therefore become the market leader.

Although the second firm now dominates the market for statins, it is not the case that the second firm's private investment in R&D is now the only relevant R&D. From the point of view of private returns, much of the early research which the initial firm carried out is indeed no longer profitable. However, in a broader sense all the initial research which demonstrated that statins were safe, highly effective, and reduced the incidence of heart disease still provides the core knowledge of the present day industry. The first firm's initial investment in R&D is still relevant to the industry and still provides important social returns, even though most of the private returns now go to the second firm.

To take another example, two leading firms have competed in producing microprocessors for many years. When the technology leader introduces a new chip, the second firm soon matches, and prices fall rapidly. As a result, microprocessor prices have declined sharply. Most of the benefits of innovation have been captured by consumers through lower prices. The profit of the innovators, obtained through returns to the R&D they conduct, is only a small part of the picture.

These examples illustrate how the knowledge and benefits obtained from R&D typically leak out from the original performers of R&D to competitors, to other firms, to consumers, and, eventually, to other countries. Many forms of knowledge are useful to other firms (and so have a social return) even when they no longer pay off to the firm initiating the research (no longer have a private return). Similarly, consumers obtain better or cheaper products (benefit from social returns) even if the private return to firms turns out to be low.

Source: Sveikauskas, L. (2007) R&D and Productivity Growth: A Review of the Literature, US Bureau of Labor Statistics Working Paper 408, BLS, Washington, DC, pp4-6.

The PACE Survey of large European firms showed that **firms rely heavily on scientific publications as a source of information about publicly funded research** (Martin *et al.* 1996), listing publications as the most important 'source and method for learning about public research', with 58.4% of respondents rating it as important – above informal contacts (51.6%), hiring (44.4%) and conferences (43.9%). Amongst the research outputs of importance to industry, 'specialised knowledge' is rated as the most important to industry with 55.7% rating it as important, ahead of other outputs of public research such as instrumentation (35.2%) and prototypes (19.4%). General knowledge from basic research was rated as important by 32.2% (Martin *et al.* 1996).

Arundel and Geuna (2004, pp569-570) re-examined data from the European PACE and Community Innovations Surveys, together with data from a Carnegie Mellon Survey, to further explore the importance of public science for firm-level innovation. They found that: “after R&D weighting, 26.4% of the 183 low technology sector respondents gave their highest score to public research, compared to 12.1% of the 190 medium technology sector respondents and 21.9% of the 120 firms in high technology sectors.” Among the highest technology firms, measured by R&D intensity, more than 57% reported that **public science was the most important source of technical knowledge for innovation**. At the other end of the scale, 23.5% of firms in the least R&D intensive sector (food) reported that public science was the most important source of technical knowledge. Across the sample, they found that publications and technical reports were rated first (*i.e.* most frequently cited as important), and they concluded that this use of “longstanding methods of information exchange point[s] to the importance of ‘open science’, in contrast to the current policy emphasis on... methods such as contract research.”

These findings suggest that the importance of public science for firm-level innovation may be understated in studies that do not weight for R&D intensity. It also appears that different avenues of public science knowledge transfer are favoured at different levels of R&D intensity, with those firms that have substantial internal R&D capacity favouring the transfer of codified knowledge in the form of publications, while those firms with little internal R&D capacity favour the transfer of tacit knowledge through collaborative and contract research. This may reflect the firms’ relative internal capacity to understand (‘decode’) codified knowledge (Laursen and Salter 2004).

A wider body of work has looked at the range of ways in which universities can have economic and social impacts and the mechanisms for knowledge exchange between universities and private and public sector organisation, communities and regions – through patents, licensing, spin-offs, science parks, training and recruitment of graduates as well as more traditional interactions, such as publications and conferences.

Hendry *et al.* (2000) focused on diffusion by means of **collaborative or network relationships between universities and SMEs**, and found that some 24% to 56% of firms in opto-electronics reported linkages of the various types examined. In relation to SMEs using universities as a source of ideas, in addition to direct spin outs, they noted the case of a firm in Arizona developing products based on original research done at the University of Southampton, concluding: “significantly, this has an international rather than local perspective, implying the importance of ‘technology watch’ and the global transfer possibilities of codified knowledge that exists in the form of research results” (Hendry *et al.* 2000).

Similarly focused on university-industry interaction, Gosh *et al.* (2006, p8), noted that university-industry interactions ranked highly for their contribution to innovation: “... the ‘conventional’ modes of university output – such as graduates, publications and conferences – are the activities most frequently cited as contributing to innovation.” Around 40% of the sampled firms in the UK and US rated publications as ‘highly important’, with the UK firms ranking publications as the 3rd most important contributor to innovations and the US firms ranking publications 4th.

These studies show the importance of publicly funded and academic research for private sector innovation and firm performance, as well as highlighting the centrality of research and technical information exchange and publications in knowledge transfer.

Access to research and technical information

There have been a number of studies exploring access issues for researchers in various fields of research, institutional and sectoral settings. In a brief review of such studies, focusing very largely on research authors (*i.e.* researchers who are also authors) access to research in developed countries, Davis (2009) found that most indicated reasonably good and improving levels access for research authors employed in developed countries, although **a significant number reported access difficulties** and/or gaps, as did those from developing countries. Among the studies noted, Rowlands and Olivieri (2006) found that 67% respondents in immunology and microbiology reported having good or excellent access (suggesting that 33% did not); and Ware (2007) found that among an international sample, 69% of respondents reported having good or excellent access (suggesting that 31% did not), and outside the US and Canada 53% of respondents reported having good or excellent access (suggesting that 47% did not).

Swan (2008) explored the access and use of UK academic ‘grey literature’ among a small sample of SMEs and found that: **“SMEs do require access to grey literature of various types** and would welcome the chance to use reports, survey results, theses and datasets that universities could provide. The problem is discoverability. SMEs turn to trade or professional bodies for this sort of information as a rule, or search the Web, and do not think of the higher education community as a possible source” (Swan 2008, p1). Swan also noted, anecdotally, that each of the research-based SMEs she interviewed raised (without prompting) issues relating to difficulties and limitations to their access to journals (Swan 2008, p13).

Ware (2009) looked at *Access by UK small and medium-sized enterprises to professional and academic literature*, although his study also included researchers and users in universities and colleges, hospitals and public health facilities, public research institutions and government departments, and other practitioners, professionals and individuals. Ware found that **SMEs rated original research articles and review papers in journals as their most important sources of information** (as did university and college based researchers). For large firms, technical information and standards were more important, but journal articles were still among the most important sources.

In relation to research article access levels and gaps, Ware (2009) found that 73% of SME respondents, 53% of large firm respondents and 27% of university or college **respondents reported having difficulties accessing research articles**. Just 2% of SMEs, 7% of large firms and 17% of higher education-based researchers reported having access to all the articles they needed for their work. Amongst those experiencing access difficulties, those difficulties affected 6% to 10% of articles read (Table 1). Of the entire sample, however, Ware concluded that the percentage of articles with access difficulties ranged between 10% and 20%, of which between 21% and 55% related to the toll access barrier. It should be noted that in Ware’s survey, 71% of SMEs reported

using Open Access journals and 42% reported using institutional repositories, so the reported access difficulties included current levels of Open Access availability and use. Hence, reported access difficulties as a share of readings may understate toll-related access barriers.

Table 1 Access to research articles (per cent)

<i>Access to research articles</i>	<i>SMEs</i>	<i>Large Firms</i>	<i>University College</i>	<i>CIBER 2004</i>
	N=186	N=111	N=470	N=3,787
Excellent (I have access to all the articles I need)	2%	7%	17%	15%
Good (I have access to most of the articles I need)	26%	39%	55%	46%
Varied (I sometimes have difficulty getting the articles I need)	56%	37%	22%	29%
Poor (I frequently have difficulty getting articles)	14%	13%	4%	8%
Very Poor (I always have great difficulty getting articles)	3%	3%	1%	2%
Experiencing access difficulties	73%	53%	27%	39%
Have access to all I need	2%	7%	17%	15%
Number reporting recent access difficulties	55%	34%	24%	..

Source: Ware, M. (2009) Access by UK small and medium-sized enterprises to professional and academic literature. Publishing Research Consortium, Bristol. (Authors' analysis).

Reporting on a series of studies, RIN (2009a) concluded that: “...**many researchers are encountering difficulties in getting access to the content they need and... this is having a significant impact on their research**” [*emphasis added*]. Looking at the detail, RIN (2009b, pp8-9) reported that more than 80% of survey respondents said that the difficulties they encountered in gaining access to content had an impact on their research, and nearly a fifth (16%) said that the impact was ‘significant’. The most common impacts reported were delays in research, and inconvenient and disruptive interruptions to workflow. Lack of access is also a hindrance to collaborative working. Peer reviewers are also hindered when they cannot access sources cited by an author, and scientists worry that lack of access to the latest findings and methodologies may lead them to undertake redundant work.

These studies show the importance of access to academic research and research articles, and suggest that **there are access limitations and barriers to access** that affect knowledge transfer and research performance.

This study of Access to Research and Technical Information in Denmark was funded by The Danish Agency for Science, Technology and Innovation (FI) and Denmark's Electronic Research Library (DEFF) to help get a better understanding of how small to medium-sized enterprises (SMEs) access research and technical information, how important it is to them, and whether SMEs have any problems in getting the information they need. A concise online survey was used in conjunction with a series of interviews to explore the views of a small sample of knowledge-based SMEs.

The sample

Research for this study involved an online survey and in-depth interviews. The survey was intended to gather information from a sample of knowledge-based SMEs in Denmark, and the interviews were intended to enable us to collect more qualitative information and follow-up on any specific issues arising from the survey responses. The interviews followed the same broad structure and covered many of the same questions as the survey, while enabling us to follow specific issues and leads as they arose.

The sample was by no means random. Drawn from contact lists supplied by The Danish Agency for Science, Technology and Innovation (FI), it focused on smaller and younger, knowledge-based firms and included a sub-set made up of firms that were currently or had previously participated in the national incubator scheme 'Innovation-smiljoerne'. The Agency provided an introduction and sent the invitation to participate in both interviews and the survey to approximately 1 000 firms. A total of 98 usable responses were received (approximately 10% response rate).

The sample for the interviews was derived from two sources. First, identification by The Danish Agency for Science, Technology and Innovation (FI) of two groups of firms: (i) that had participated in Denmark's national incubator scheme 'Innovation-smiljoerne'; and (ii) non-incubator firms. Second, respondents to the online survey who expressed an interest in a follow-up interview and whose questionnaire answers raised issues central to the study topic. There were a total of 23 interviews conducted (13 with incubator firms, 10 with non-incubator firms).

There are a number of important caveats. First and foremost is the fact that **this is not a large or random statistical sample** and should not be interpreted as representative of SMEs in general or even of knowledge-based SMEs. Rather, it is an attempt to better understand the information access needs and concerns of a category of enterprises of interest to The Danish Agency for Science, Technology and Innovation (FI) and Denmark's Electronic Research Library (DEFF). In view of this, no attempt is made at statistical analysis. We simply report responses as a percentage of total respondents/responses, the number of which ('N') is report for each question. Sample size is contextual, and Denmark is a relatively small country. Second, as incubator firms are often located at or near universities in Denmark, and often have close ties to those universities, one might expect them to have better access to academic research than might be typical of the wider population of firms. Of course, one might also expect them to have greater access needs.

Despite these caveats, the interview and questionnaire responses we obtained are similar to those reported in a number of previous studies around the world, suggesting that our findings are reasonably robust.

The questionnaire

Previous studies of research and information access have focused on the information types sought and used, and access issues experienced by various actors, including academic research staff and people in industry. These studies have not attempted to value the access beyond respondent ratings on a scale of importance. The exception was a study by Mark Ware (2009), which looked at *Access by UK small and medium-sized enterprises to professional and academic literature*. Ware included a section in his survey that explored the importance of access to various types of information for a range of “success factors”. However, he did not define success and was less than entirely successful in linking access to the success factors.

Moreover, Ware’s questionnaire contained two important shortcomings: (i) it conflated journals and articles, when it is not necessary to access journals to access articles and emerging business models are increasingly separating the two (e.g. ‘Green’ Open Access self-archiving provides Open Access to articles while ‘Gold’ Open Access provides Open Access to journals, and subscription payments provide toll access to journals while pay-per-view provides toll access to articles); and (ii) some questions tended to confuse and/or conflate discovery and access.

For this study we have refined some of the core questions from Ware’s study, in order to avoid the confluences noted above, and added a set of innovation questions from Mansfield (1991; 1998) and subsequent Innovation Surveys (OECD/EuroStat 2005), which aim to shed light on the value of access to the firms and its converse (i.e. the implied cost of access gaps).

The questionnaire and interviews addressed three main topics, each forming a section including a number of questions. Following a brief introduction to the topic, the sections were as follows:

- *Demographics*: A short section seeking basic information about the firms and respondents, including firm size, annual revenue, R&D spending, industry sector and the respondents’ roles within the firm.
- *Information needs and levels of access*: The questions in this section were designed to explore the respondents’ information needs, how they discover information and access that information, the importance of that information to them, and whether there are any access gaps or barriers. In order to focus on the issue of communication and dissemination of publicly funded research, the focus was on *research articles* of the kind typically representing the findings of academic and public sector research.
- *Importance and value of access to research information*: The questions in this section were designed to help us understand the importance of access to research information for the respondents’ firms. In particular, we were interested in the extent to which the information found in *research articles* contributes to innovation and the value of that innovation to the firms.

The full questionnaire can be found in the *Annex to Report* (Annex I).

The section summarises findings from the survey and interviews. A detailed question-by-question presentation of survey results, which presents responses for (i) all respondents, (ii) researchers, (iii) incubator firms and (iv) innovating firms (*i.e.* those having introduced new or improved products or services in the last three years), can be found in the companion *Annex to Report* (Annex II).

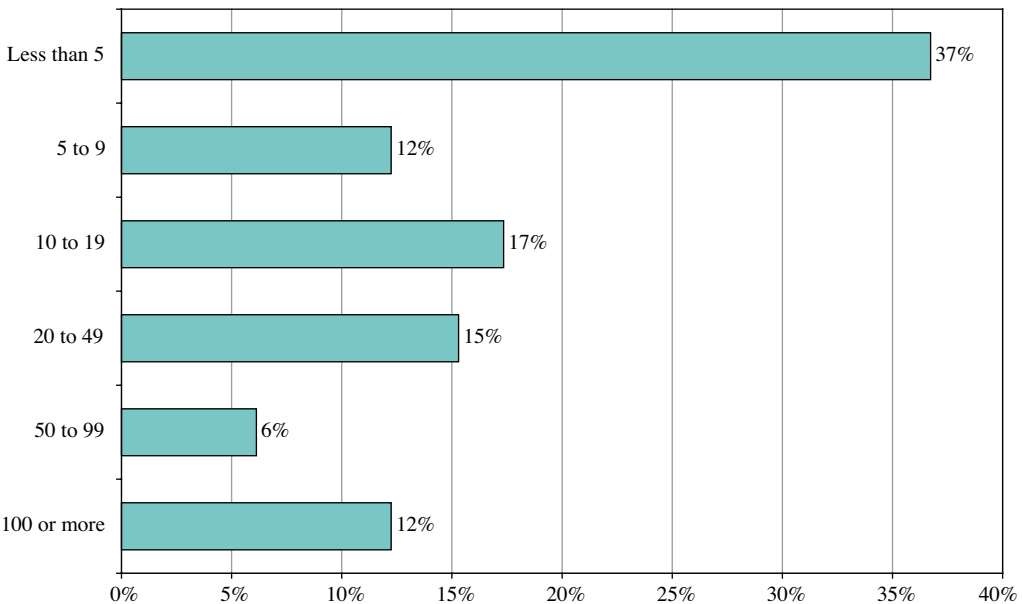
The survey

There were a total of 98 usable responses, although not all respondents answered all of the questions and some questions sought multiple responses, and in these cases it is the share of total responses that is reported. Hence, wherever the presentation deviates from N=98 it is noted. Wherever there are important differences between sub-categories of respondents they are also noted. Given the low response numbers, no attempt is made at statistical analysis.

Demographics

The survey began with questions about the respondents and their firms. Most firms were small and many were recently established. One-third reported that they were currently or had at some time been participants in the national incubators scheme “Innovationsmiljøerne” or similar (N=92).

Figure 1 Size of firms (number of employees)



Source: Survey on Access to Research and Technical Information in Denmark (Authors’ analysis).

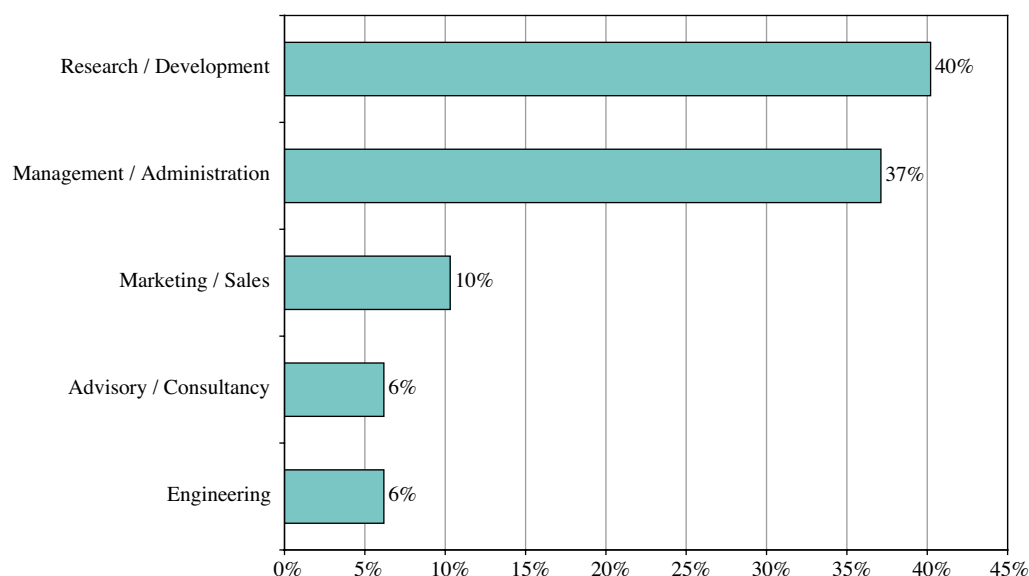
The firms were typically small, with 37% reporting fewer than five employees and a further 12% reporting between five and nine – although 12% reported employing 100 or more people (N=98) (Figure 1). Not surprisingly, the incubator firms were smaller, with 73% reporting fewer than 10 employees, while 44% of innovating firms (*i.e.*

those having introduced new or improved products or services in the last three years) reported fewer than 10 employees.

The year of establishment of the respondents' firms ranged from 1861 to 2010. Two firms reported establishment in the 19th century, 45 in the 20th century and 49 were established since 2000, including 34 since 2005 and four during 2010 (N=97).

Respondents were mainly in research and/or management, with 40% reporting research roles and 37% management (N=97). However, it is worth noting that in a number of the respondents from smaller firms performed multiple roles and sometimes, as single proprietor, all roles. A few respondents were in specialist marketing and sales, engineering and advisory roles (Figure 2).

Figure 2 Main role of the respondents in their firm



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Sixty-four per cent described their activities as manufacturing, 21% as services and 16% as software/content (N=96). These proportions were similar amongst the incubator and innovating firms. At a more detailed level, 24 firms categorized their activities as manufacturing, nine as construction, information and communication, and knowledge-based services, seven as human health and social work, and 14 other services (N=91).

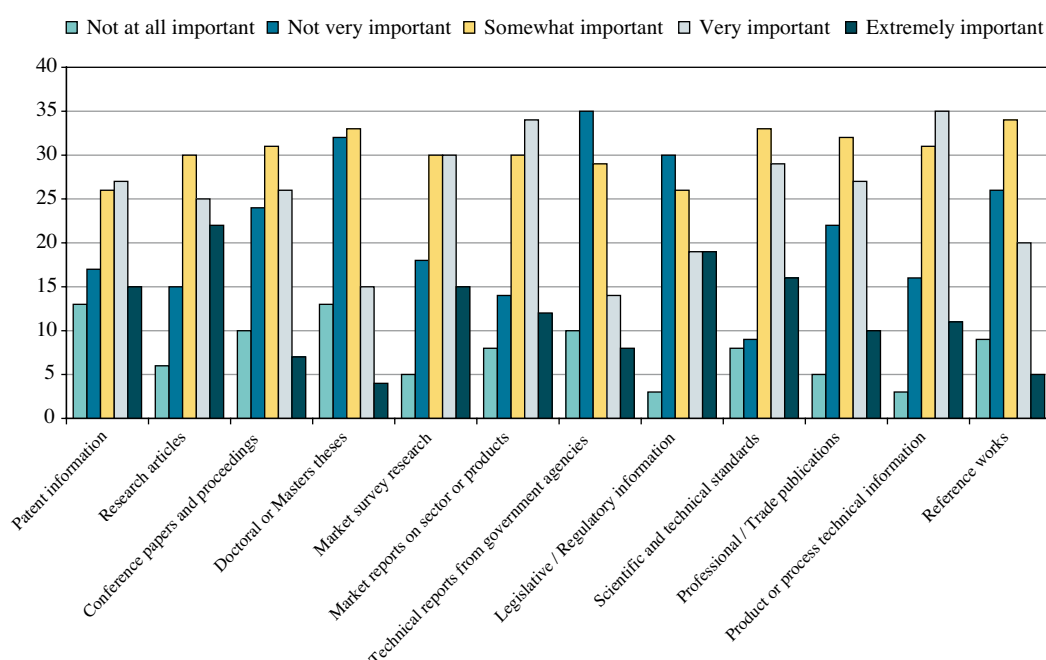
Reported **annual sales revenue varied widely**, with a number of start-up firms not yet making sales and reporting zero sales revenue and 12 firms reporting sales revenue in excess of DKK 100 million per year. The average across the sample was around DKK 130 million per year (N=90). Incubator firms reported a lower average of DKK 71 million per year, and innovating firms a higher average DKK 158 million per year.

Reported **R&D spending also varied**, from little or none to as much as DKK 80 million per year. A number of early stage firms reported R&D spending greater than sales and a small number of start-up firms reported R&D spending of DKK 3 to 7 million per year and zero revenue from sales. Overall, the firms reported average annual R&D spending of DKK 5.7 million on sales of DKK 130 million, or 4% (N=81). Reflecting their focus on innovation, incubator firms reported spending a higher average DKK 7 million per year (equivalent of 10% of sales revenue).

Information access

The second section of the questionnaire explored the respondents' information needs, how they discover and access information, and whether there are any barriers to access or gaps in what is available to them. Questions were designed to tease out the issues of importance of access, ease of access and problems/costs of access. Self-evidently, something that is important and difficult to access is of more significance than something that is not important, whether difficult to access or not. Figure 3 shows the respondents' ratings of the importance of various information types (N=98).

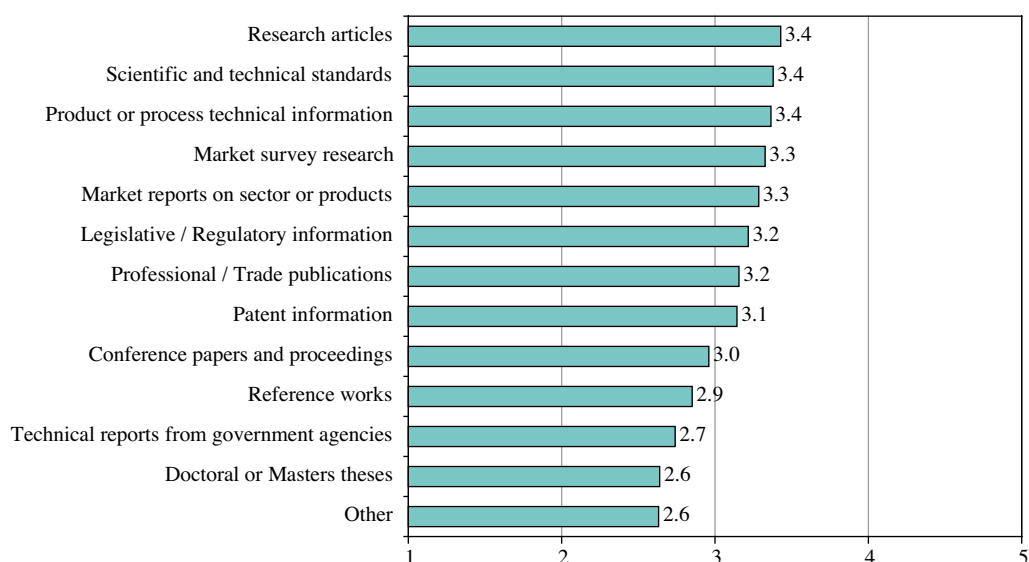
Figure 3 Importance of each information type



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Asked to rate the importance of various types of information on a scale from 1 (not at all important) to 5 (extremely important) respondents' rated research articles, scientific and technical standards, and product or process technical information highest (average score 3.4), followed by market survey research and market reports on sector or products (average score 3.3), and legislative/regulatory information and professional and trade publications (average score 3.2). All information types listed were deemed important, with the lowest average score being 2.6 (Figure 4).

Figure 4 Average importance rating on a scale of 1 (not at all important) to 5 (extremely important)

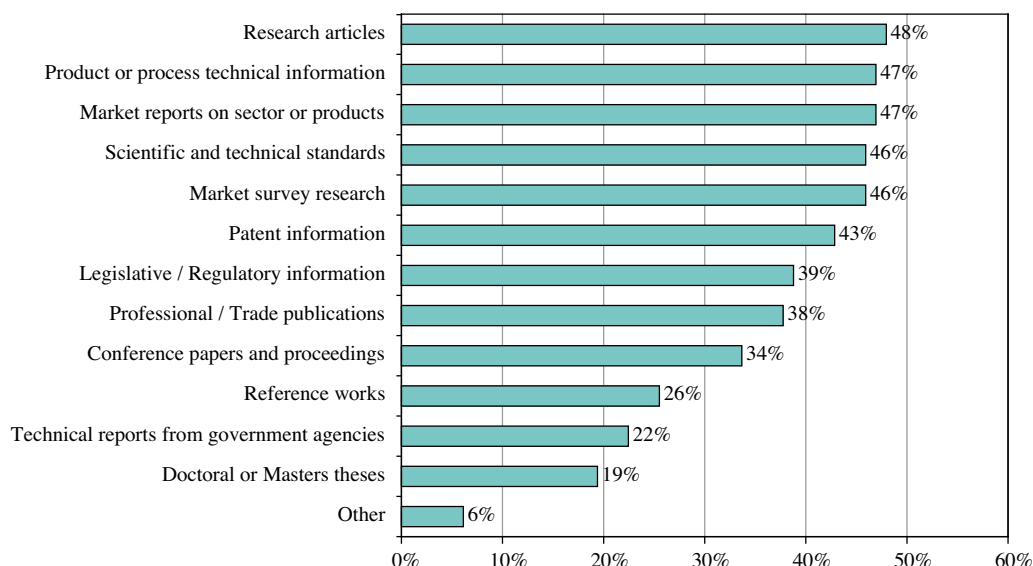


Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Forty-eight per cent of respondents rated research articles as very or extremely important, 47% rated product or process technical information and market reports on sectors or products as very or extremely important, 46% rated scientific and technical standards and market survey research as very or extremely important, and 43% rated patent information as very or extremely important (Figure 5). The 'other' sources mentioned included: legislative information on foreign countries, and information about international trade (*e.g.* customs, import/export documents, shipping, trade regulations, etc.).

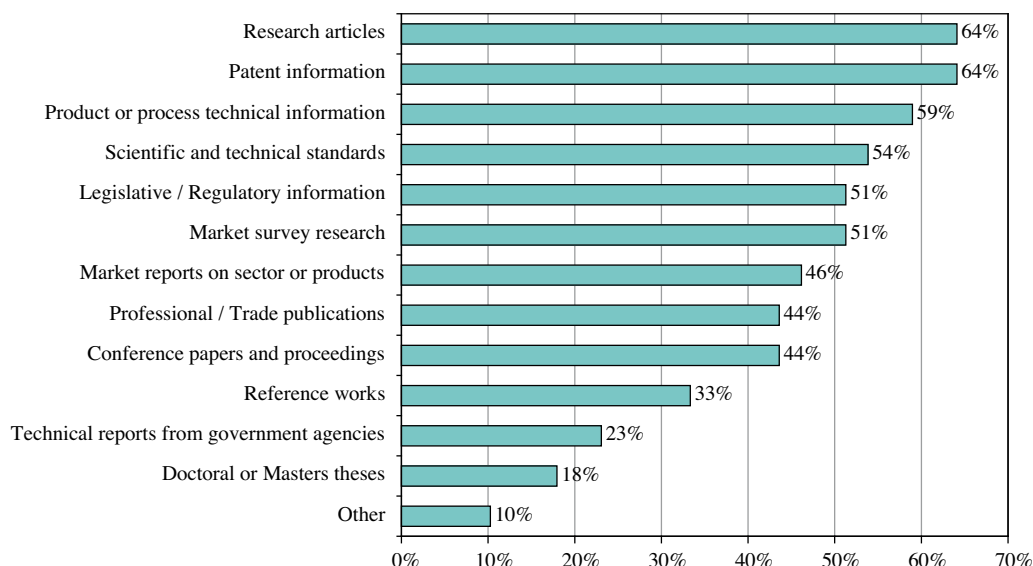
Among those respondents who were in research roles (N=39), a higher 64% rated research articles and patent information very or extremely important, followed by product or process technical information (59%), scientific and technical standards (54%), and legislative/regulatory information and market survey research (51%) (Figure 6). Research articles also had highest average score among researchers (3.8), as well as being rated the most important information source by innovating firm respondents.

Figure 5 Percentage rating information type as very or extremely important



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Figure 6 Percentage of researchers rating information type as very or extremely important



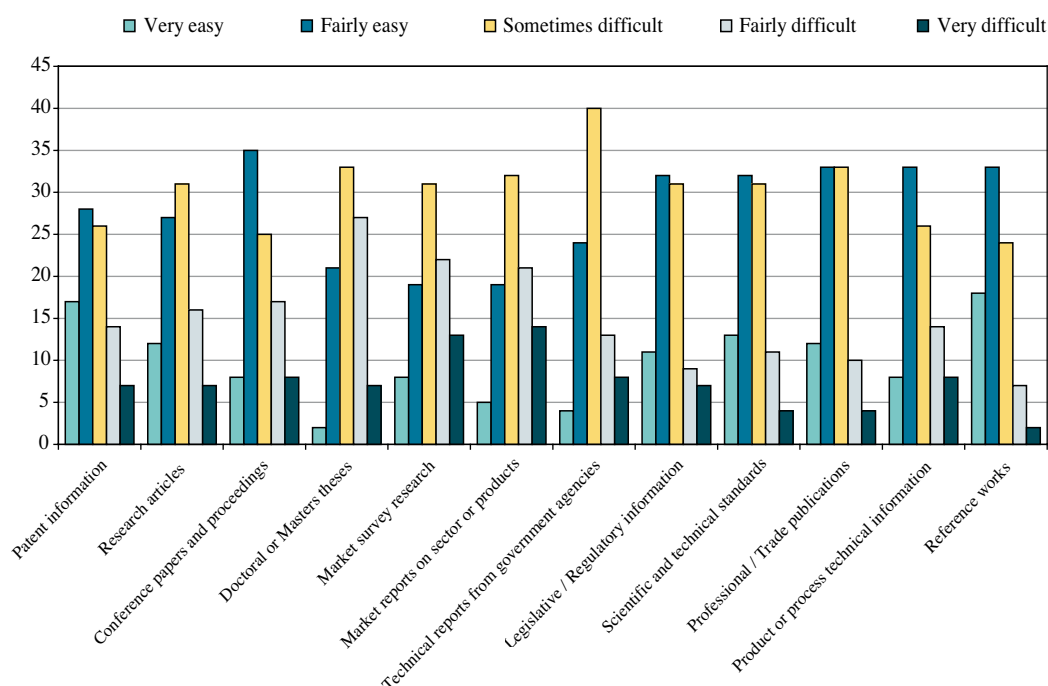
Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Among the 30 incubator firms, market survey research was more important – being rated very or extremely important by 70%, followed by market reports on sector or products and patent information (67%).

Asked how easy it was for them to gain 'full text' access to these various types of information on a scale of 1 (*very easy*) to 5 (*very difficult*), it was clear that many experience some access difficulties (Figure 7) (N=95). Asked to rate the ease of gaining access to the 'full text' of various types of information on a scale from 1 (*very easy*) to

5 (*very difficult*) respondents' rated reference works (average score 2.3), scientific and technical standards, professional/trade publications and patent information (average score 2.6) the easiest to access in full, followed by legislative/regulatory information (average score 2.7). Market reports on sector or products and Doctoral or Masters theses (average score 3.2) were reported to be the most difficult of the information types to access in full (Figure 8).

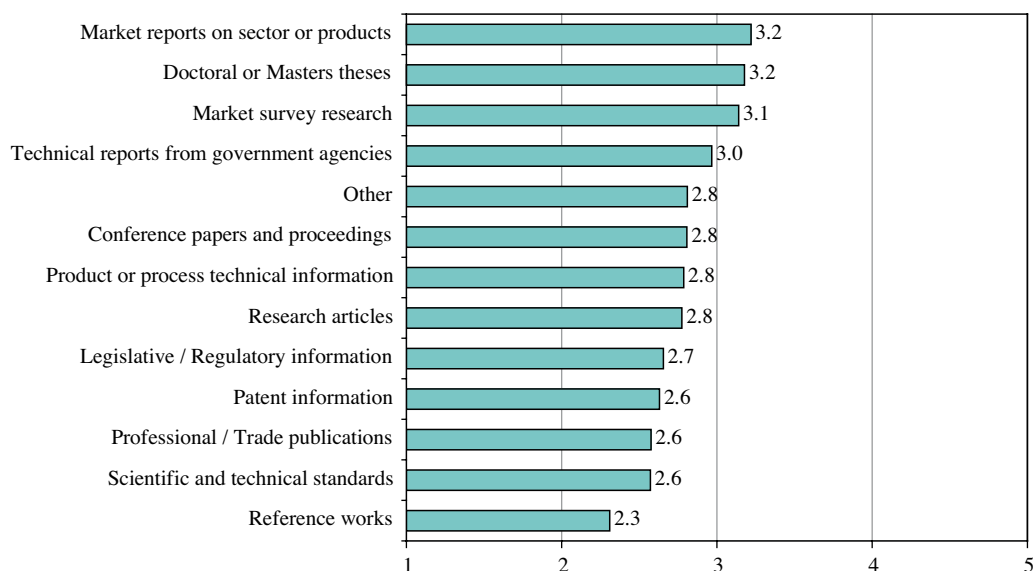
Figure 7 Ease of access to each information type



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

More than two-thirds of respondents reported having access difficulties (*i.e.* reporting access to be sometimes difficult, fairly difficult or very difficult) when accessing market reports on sector or products, market survey research and Doctoral or Masters theses, 62% reported difficulties accessing technical reports from government agencies, and 55% reported difficulties accessing *research articles* (Figure 9).

Figure 8 Average access difficulty rating on a scale of 1 (very easy) to 5 (very difficult)



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Figure 9 Percentage for who access is very, fairly or sometimes difficult



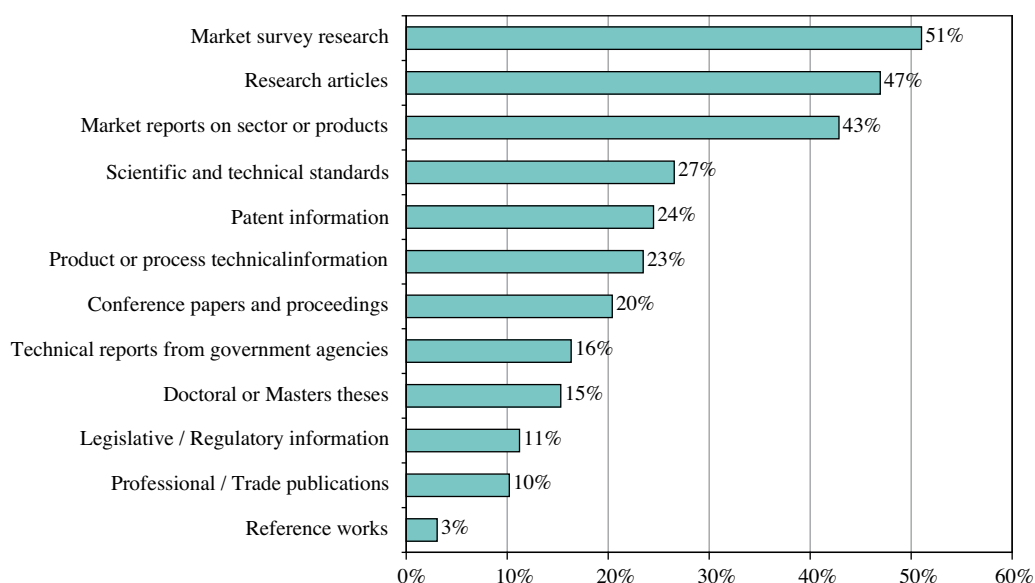
Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Comparing Figures 6 and 9, suggests that the things that are both important and difficult to access include research articles, market survey research and market reports on sector or products. In contrast, Doctoral and Masters theses present access difficulties, but are not regarded as very important. This is borne out in responses to the next question.

To further explore their access needs and priorities, respondents were **asked to which of the information types they would like to have improved access**. More than

50% sought better access to market survey research, 47% sought improved access to research articles, and 43% sought improved access to market reports on sector or products (N=92). Twenty per cent or more sought improved access to scientific and technical standards (27%), patent information (24%), product and process technical information (23%), and conference papers and proceedings (20%) (Figure 10).

Figure 10 Percentage of respondents wanting improved access by information type

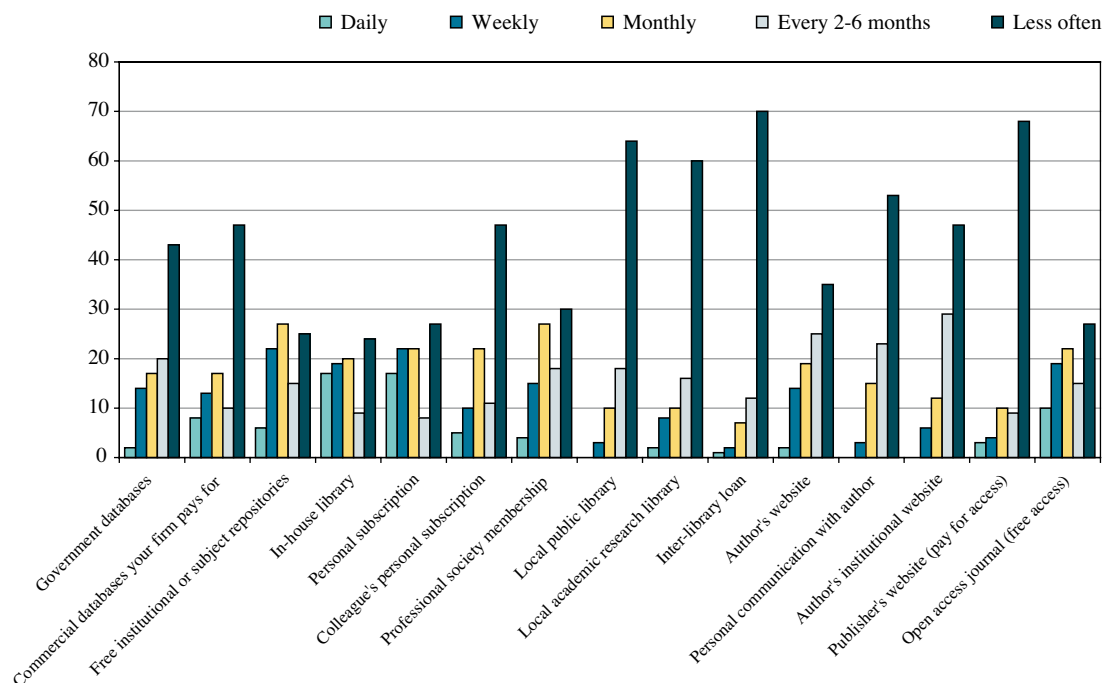


Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Among researcher respondents, improved access to *research articles* was most important – sought by no less than 59%. Market reports on sector or products and market survey research were a more important focus for improved access among the incubator firms – sought by 50% and 43%, respectively. Nevertheless, 40% of respondents from incubator firms sought improved access to *research articles*. Market survey research was also important for innovating firm respondents, although 52% sought improved access to *research articles*.

Turning to search and discovery and frequency of access and use, respondents were **asked how frequently they used various means of access to the information they need**. In-house libraries and personal subscriptions were the most commonly used access means, followed by Open Access journals and free institutional or subject repositories, and professional society membership (Figures 11 and 12). The least frequently used methods include inter-library loan, local public library and publishers' websites (e.g. pay for access).

Figure 11 Frequency of access by access method

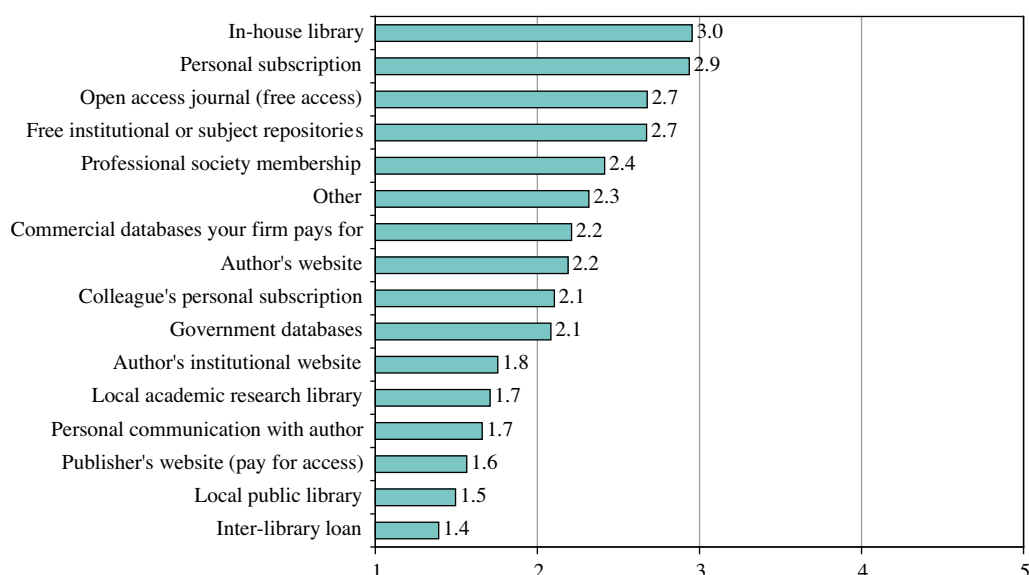


Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Some 62% of respondents reported using personal subscriptions monthly or more frequently, between 50% and 60% of respondents reported using an in-house library, free institutional or subject repositories and Open Access journal (free access), and 47% professional society membership. Just 17% reported using pay-per-view access from publishers' websites, and less than 15% reported using inter-library loans or the local public library monthly or more frequently (Figure 13). The 'other' methods of access reported included one report of direct communication with R&D departments of relevant companies and institutions, and, perhaps rather confusing discovery and access, four reports of Google or Google Scholar.

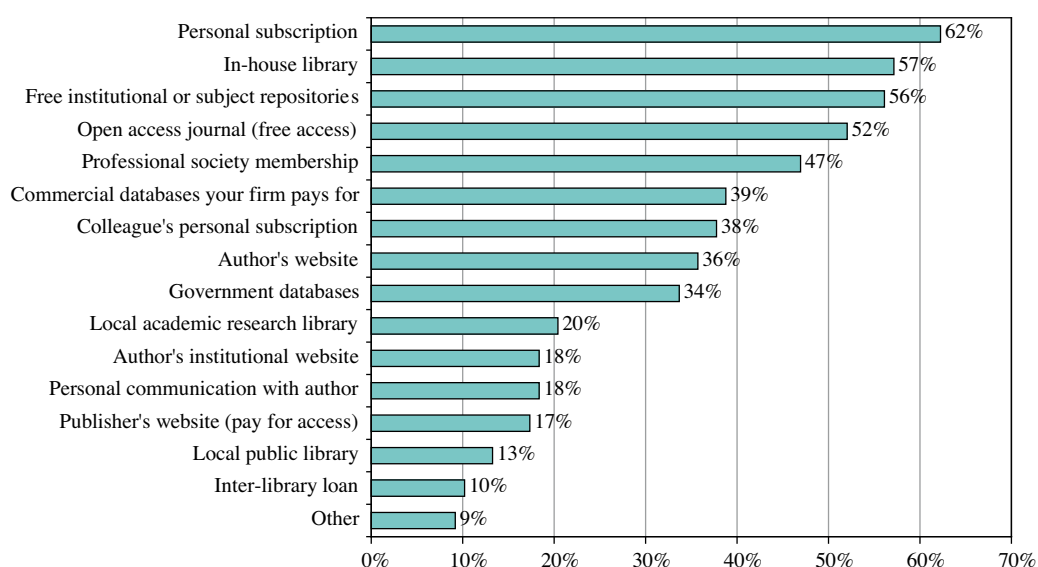
Among the researchers, 72% reported using free institutional or subject repositories monthly or more regularly, 64% personal subscriptions, and 56% Open Access journals and in-house library. Open Access materials were also widely used by incubator firms, with 73% using free institutional or subject repositories monthly or more regularly and 67% Open Access journals.

Figure 12 Average frequency of access by method on a scale of 1 (less often than every 2-6 months) to 5 (daily)



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Figure 13 Percentage of respondents using these access methods monthly or more frequently



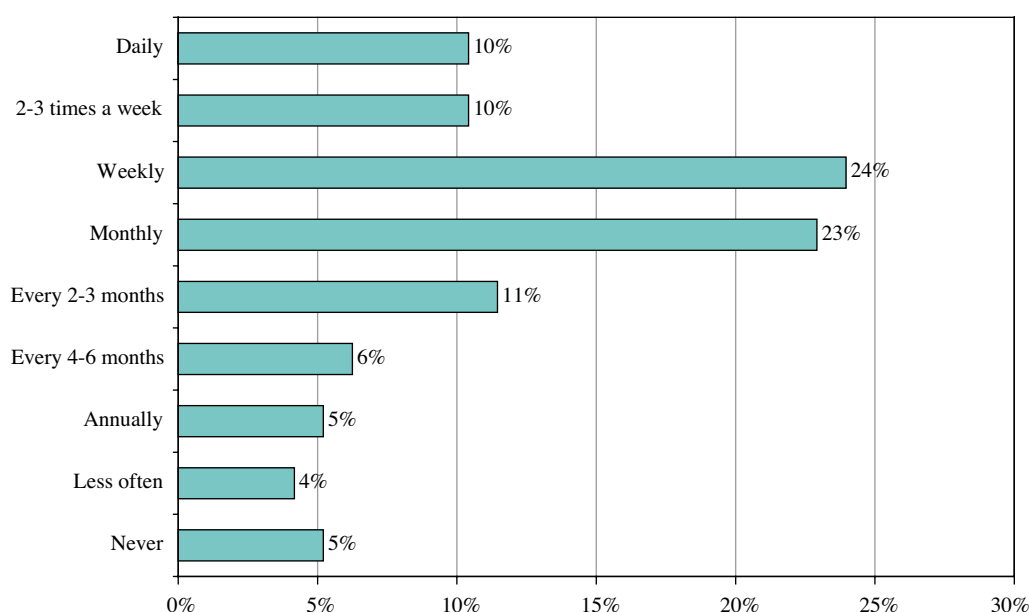
Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

The use of Open Access materials appears to be substantial, but a caveat may be in order as it is not entirely clear what level of understanding of Open Access alternatives informs these responses. For example, it is not clear that respondents finding freely available articles through a generic search engine fully understand where they are coming from. Consequently, responses indicating use of free institutional or subject repositories and Open Access journals may not be an entirely reliable indicator of the

levels of use of ‘Green’ and ‘Gold’ Open Access routes. Nevertheless, the responses do indicate the level of use of openly accessible material (however it is being made openly accessible). Moreover, Ware (2009) found that 71% of UK-based SMEs reported using Open Access journals and 42% institutional repositories/online preprints. Hence, these reported levels of use of Open Access alternatives are similar.

Looking specifically at access and use of *research articles*, respondents were **asked how often they read or consulted research articles**, either in journals or individually, and in either print or electronic form. The focus of the question on ‘research articles’ was intended to avoid any confusion/conflation of journals and articles (*i.e.* to make it clear that article access can be independent of journal access, such as through Open Access archiving). The wording ‘read or consulted’ was intended to cover full text access, whether it was for skimming the contents or reading in-depth.

Figure 14 Frequency of reading or consulting research articles



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

No less than **68% of respondents reported reading or consulting research articles on a monthly or more regular basis**, 45% on a weekly or more regular basis and 10% on a daily basis (N=96) (Figure 14). Among researchers the use of research articles was even more regular, with 85% reporting reading or consulting research articles on a monthly or more regular basis, 59% on a weekly or more regular basis and 15% on a daily basis (N=39). Similarly, Ware (2009) reported that 86% of UK-based SME researchers reported reading journal articles monthly or more often.

Asked how many research articles they read or consult each year, respondents offered a wide range of responses. However, the responses to these questions presented some challenges: Two respondents reported reading or consulting “many” articles and one reported reading or consulting “a few hundred”, but having not specified a number these could not be included in the counts; and there were two ‘unusual’ responses,

with one reporting reading or consulting 2 000 articles per year and having difficulty accessing 75% of them, and another reporting reading or consulting 800 and having difficulty accessing 1 000, which could occur if the respondent gave up on trying to access 200. Excluding these responses, **the average across the sample was reading or consulting 53 articles per year** (N=81), with specialist researchers reporting reading or consulting a higher average of 73 articles per year (N=35), and incubator firms 63 articles per year (N=24).

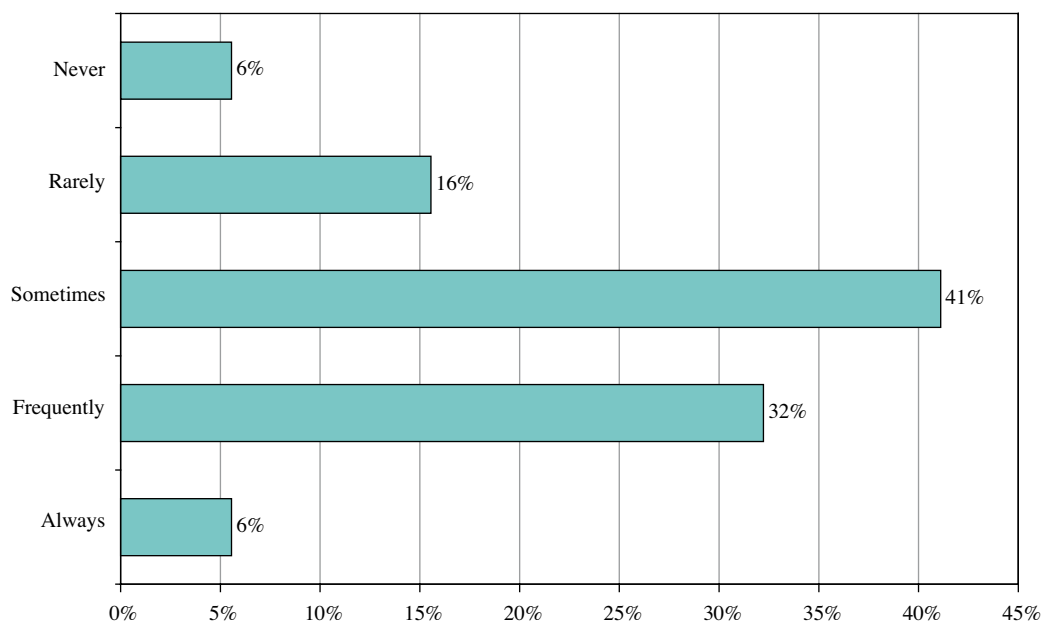
There can be no doubt that excluding the problematic responses results in lower numbers than would otherwise be the case. If the last two problematic responses were included, the average across the sample would be 85 articles read or consulted per year (N=83), with specialist researchers reporting a higher average of 145 articles per year (N=37), and incubator firms 140 articles per year (N=25). Given our somewhat broader wording ‘read or consult’, these higher averages are comparable with average article readings reported in other studies around the world (Tenopir and King 2000 and subsequent ‘Tracking Studies’).

Asked about the frequency of access difficulties relating to research articles, 38% of respondents said they always or frequently had difficulty getting the research articles they needed, and a further 41% said they sometimes had difficulties. Just 6% reported that they never experienced access difficulties (N=90) (Figure 15).

Among researchers, a higher **41% of respondents said they always or frequently had difficulty** getting the *research articles* they needed, and a further 41% said they sometimes had difficulties; and among incubator firms, 47% of respondents said they always or frequently had difficulty getting the research articles they needed, and 32% said they sometimes had difficulties. For innovating firms the percentages were 41% and 42%, respectively.

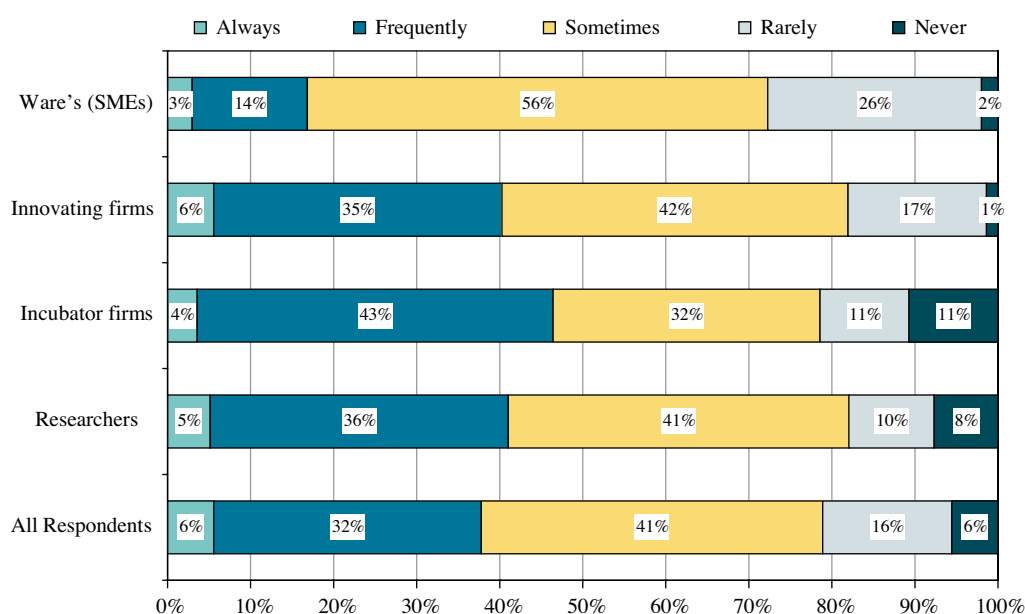
While not strictly comparable due to differences in the wording of the question and our explicit reference to accessing the ‘full text’, it is interesting to compare these results with those from a survey of UK-based SMEs conducted by Mark Ware during 2009 for the Publishing Research Consortium (Ware 2009). With the exception of the percentage reporting frequently having access difficulties (lower) and sometimes having access difficulties (higher), Ware’s results are broadly similar when one takes account of relative firm size and explicit focus on full text access (Figure 16).

Figure 15 Frequency of access difficulty relating to research articles



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Figure 16 Comparison of frequency of access difficulties by group



Sources: Survey on Access to Research and Technical Information in Denmark (Authors' analysis), and Ware, M. (2009) Access by UK small and medium-sized enterprises to professional and academic literature, Publishing Research Consortium, Bristol. (Authors' analysis).

The number of *research articles* respondents had difficulty accessing during the last year varied from 1 or 2 up to 200 and more. Excluding the problematic responses noted above, the average was **21 articles presenting difficulties during the last year**

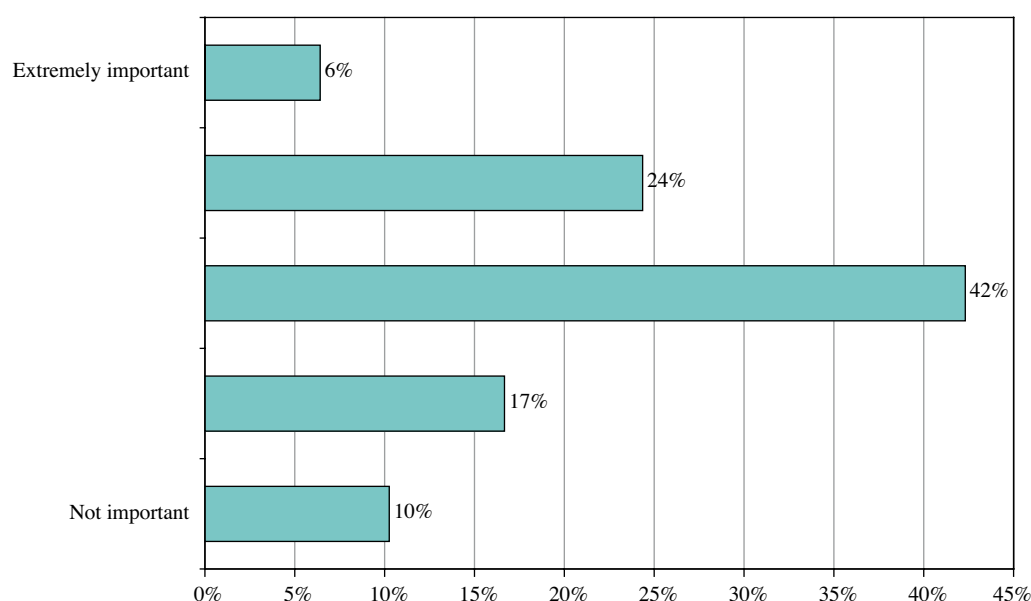
(N=68). Given that they report reading or consulting an average of 53 articles per year, access difficulties were equivalent to 39% of readings (including Open Access article readings).

Among researchers, an average of 17 articles presented difficulties during the last year, **equivalent to 23% of readings** (including Open Access article readings), and incubator firms reported an average of 30 articles present difficulties, equivalent to 48% of readings (including Open Access article readings). While these percentages are somewhat higher than reported by Ware (2009), when one takes account of relative firm size and our explicit focus on ‘full text’ access they appear comparable.

If the problematic responses were included, the average would be 56 articles presenting difficulties during the last year, equivalent to 65% of readings (including Open Access article readings). Among researchers, the average would be 99 articles presenting difficulties during the last year, equivalent to 68% of readings (including Open Access article readings), and among incubator firms the average would be 104 articles presenting difficulties, equivalent to 74% of readings (including Open Access article readings). These percentages are elevated by the unusually large numbers reported in the two problematic responses (See discussion above).

Respondents attached importance to the *research articles* they had difficulties accessing (N=78) (Figure 17).

Figure 17 Importance of the last article presenting access difficulties on a scale of 1 (not important) to 5 (extremely important)



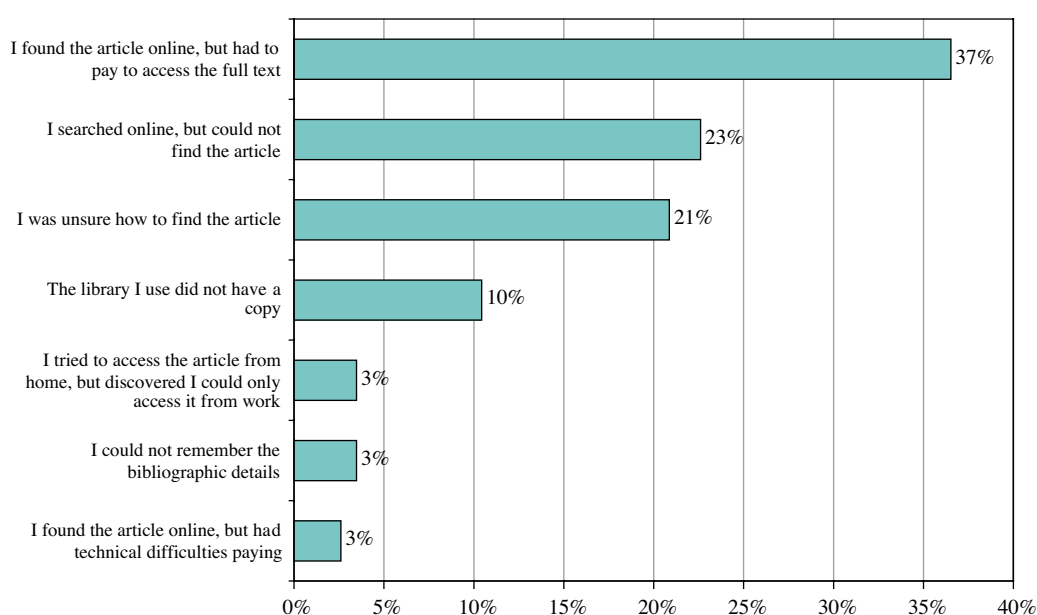
Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

The main difficulties encountered in relation to the last *research article* respondents had difficulty accessing included:

- I found the article online, but had to pay to access the full text (37%);
- I searched online, but could not find the article (23%); and
- I was unsure how to find the article (21%).

Approximately 53% of difficulties encountered relate in some way to toll access barriers (Figure 18). Among researchers approximately 64% of difficulties relate in some way to toll access barriers, among incubator firms it was 63% and among innovating firms it was 54%. The high percentage of respondents (circa 44%) reporting that they searched but did not find and/or were unsure how to find suggests that there is a need for higher-level information literacy skills and/or support.

Figure 18 Access difficulties encountered (percentage of responses)



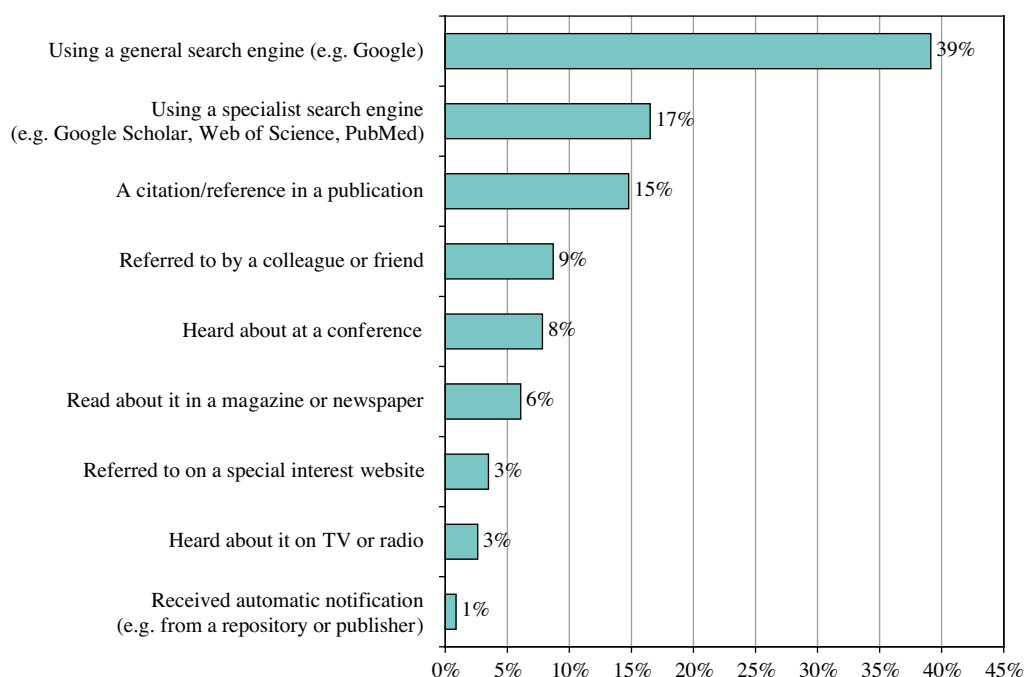
Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

The main means of discovery of the last *research article* respondents had difficulty accessing were:

- Through the use of a general search engine (*e.g.* Google) (39%);
- Using a specialist search engine (*e.g.* Google Scholar, Web of Science, PubMed) (17%);
- A citation/reference in a publication (15%); and
- Referred to it by a colleague or friend (9%) (Figure 19).

The use of a general search engine (*e.g.* Google) was by far the most widely cited discovery mechanism, cited by 38% of researcher, 39% of innovating firms, and 49% of incubator firms.

Figure 19 Discovery of articles presenting access difficulties



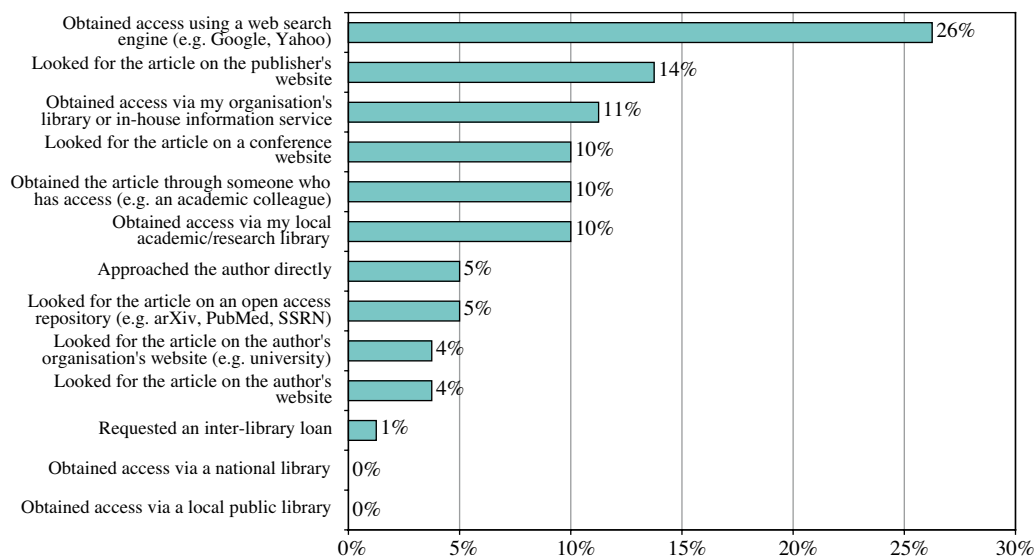
Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Asked what they did to obtain the 'full text' of the last *research article* they had difficulty accessing, respondents reported that they:

- Obtained access using a web search engine (*e.g.* Google, Yahoo) (26%);
- Looked for the article on the publisher's website (14%);
- Obtained access via my organisation's library or in-house information service (11%);
- Looked for the article on a conference website (10%);
- Obtained the article through someone who has access (*e.g.* an academic colleague) (10%); and
- Obtained access via my local academic/research library (10%) (Figure 20).

The 'other' avenues reported by respondents included: bought it from an online book-shop, found the requested information elsewhere, and looked for another article. Four reported giving up, one saying they gave up because the article was too expensive.

Figure 20 Access approaches used for articles presenting access difficulties



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Asked how long they spent trying to access the last *research article* they had difficulties accessing, responses ranged from 2 minutes to 5 hours and more. The **average time was 51 minutes** (N=67). Among researchers, the average time was 63 minutes (N=28).

Salary and overhead costs vary, but at the average total cost of researchers in Denmark circa 2008, 51 minutes would cost DKK 917 and 63 minutes DKK 1 133. If around 60 minutes were characteristic for researchers in general, then the time spent dealing with access difficulties might be costing around DKK 540 million per year among specialist researchers alone.²

Basis for estimate

R&D expenditure in 2008 of DKK 54 billion with 29 785 FTE research staff working 1 680 hours per year gives an hourly total cost of DKK 1 079. Researcher respondents reported an average of 17 articles presenting difficulties in the last year.

Hence:

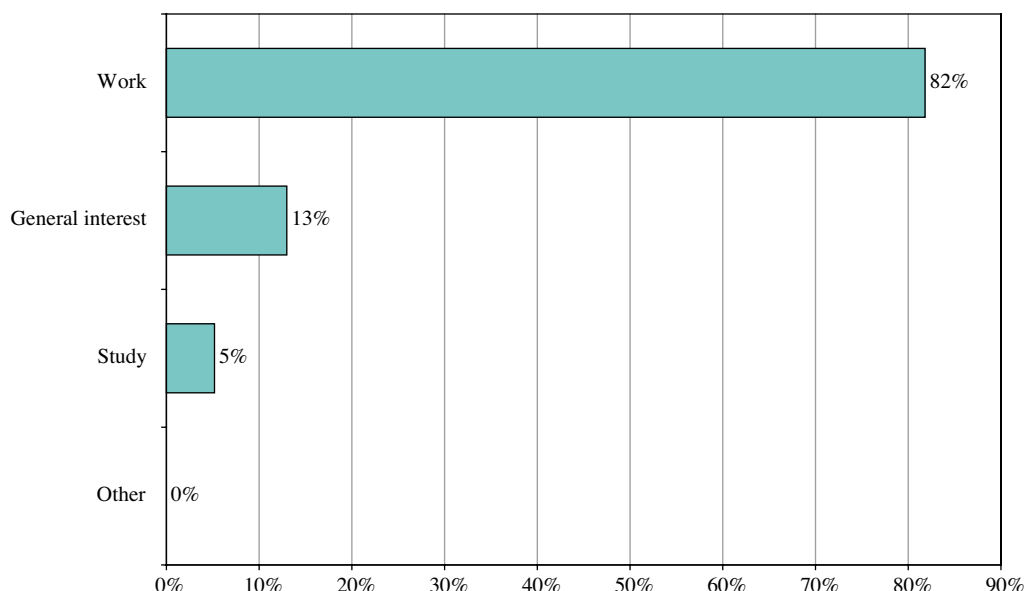
$$(29\,785 \times 17) \times 1\,079 = 541\,836\,735$$

Source: R&D data sourced from EuroStat. (Authors' analysis).

The vast majority of respondents **intended to use the last *research article* they had difficulty accessing for work purposes** (82%) (N=77).

² Or as much as DKK 3 billion, if the problematic responses to Questions 14 and 16 were included.

Figure 21 Intended use of the last article presenting access difficulties



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Twenty-nine of the 35 respondents (83%) **commenting on the typicality of their experience with the last research article presenting access difficulties** said that the experience was typical. Most of the others did not respond, although a few responded with explanations as to why it was not possible to say whether it was typical or not. Just three said that the experience was not typical (*i.e.* answered “no”).

Looking at total access expenditures on *research article* access, **respondents were asked about corporate and personal subscription and pay-per-view expenditures**. They reported:

- Average corporate journal subscription spending of DKK 3 912 per year (N=64);
- Average corporate pay-per-view spending of DKK 1 578 per year (N=60);
- Average personal subscription spending of DKK 758 per year (N=62); and
- Average personal pay-per-view spending of DKK 296 per year (N=54).

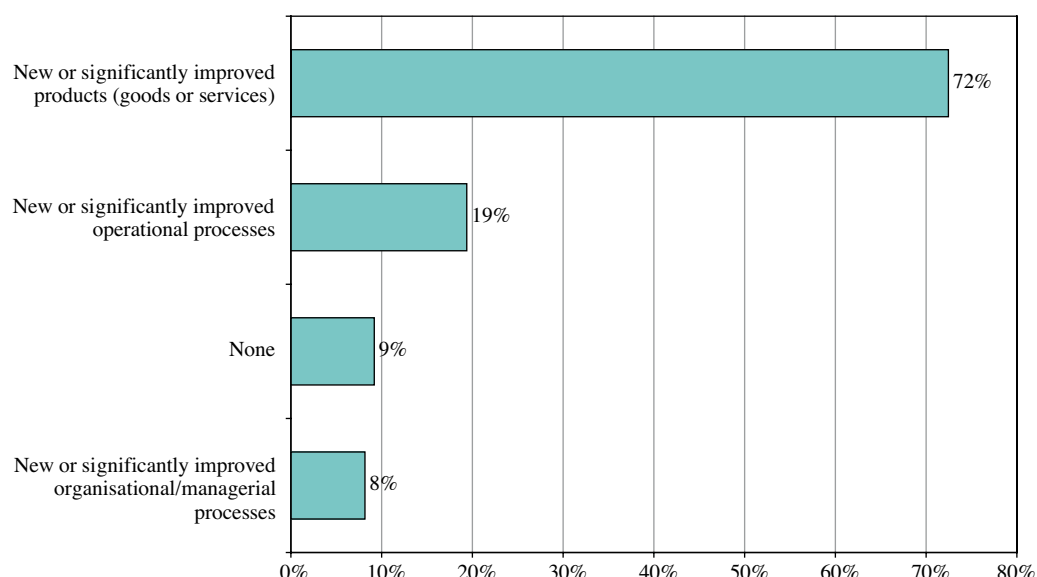
Among researchers, reported corporate spending was somewhat lower and personal spending somewhat higher.

Questions in this section were designed to help us understand how important access to research information is for the firms. We were interested in the extent to which the information found in research articles contributes to innovation and the value of that innovation to the firms. In particular, we wanted to know how important access to academic research is for the timeliness of product or service development and about delays or failures in product development that could be due to barriers to access to

academic research. We were interested in products and processes developed by the firms and/or developed externally and introduced by the firms (*i.e.* in the impacts on innovation as well as research). Questions were based on those originally used by Mansfield (1991; 1998) and refined through subsequent innovation surveys (OECD/EuroStat 2005). These questions are difficult to answer, especially for new start-up firms, and a number of respondents did not respond and/or commented on the difficulties they had in responding.

The firms were innovative. Seventy-two per cent reported **introducing new or improved products or services during the last three years**, 19% had introduced new or improved operational processes, and 8% had introduced new or improved organizational or managerial processes (Figure 22). Just 9% had not introduced innovations during the last three years (N=98).

Figure 22 Introduction of new products, services and processes



Source: Survey on Access to Research and Technical Information in Denmark (Authors' analysis).

Respondents suggested that an average of **27% of the products developed or introduced during the last three years would have been delayed or abandoned without access to academic research** (N=62). Research respondents reported a higher average of 38% of the products developed or introduced during the last three years would have been delayed or abandoned without access to academic research, and incubator firms reported a still higher average 42% – attesting to the importance of academic research for innovative firms. Comments included:

- Articles are used to establish the foundation and understand development issues.
- It is impossible to conduct hi-tech research without access to academic papers.
- We would still have developed the product, but with greater difficulties.
- We are not bothered by lack of access to articles or research. We develop, but not at such an advanced level.

The latter is interesting, as it makes a distinction between research and development and suggests the potential to move to a higher level of knowledge-intensity where access to academic research would be more important.

Mansfield (1998, p774) reported that, across a sample of US firms and spanning the period from 1975 to 1994, a very similar 22% to 23% of new products could not have been developed without substantial delay in the absence of academic research and/or were developed with substantial aid from recent academic research.

Respondents said that **products developed or introduced in the last three years had contributed or would contribute around 46% of annual sales** (N=74). Research respondents reported a higher average 55% of sales, incubator firm respondents reported an average 62% and innovating firm respondents 45%.

Total reported sales were an annual average DKK 130 million per firm (DKK 11.7 billion in total across the sample). Hence the annual sales of new products and services were worth around DKK 60 million per firm (DKK 5.4 billion in total across the sample). If 27% of these depended on academic research (Question 29), then the value of academic research to sales was approximately 12%, or around DKK 16 million per firm per year (DKK 1.4 billion per year in total across the sample).

Mansfield (1998, p775) reported that, across a sample of US firms and spanning the period from 1975 to 1994, new products that could not have been developed without substantial delay in the absence of academic research and/or were developed with substantial aid from recent academic research contributed around 9% of sales. This is broadly when our focus on small innovative and incubator firms is taken into account.

An average of 19% of the **processes developed or introduced over the last three years would have been delayed or abandoned without access to academic research** (N=60). Researchers reported that a higher average 34% of the processes developed or introduced over the last three years would have been delayed or abandoned without access to academic research, and incubator firms 32%. Comments included: the access to information is an important complement, when you wish to prove and include all benefits that new inventions would provide to the customers.

Mansfield (1998, p774) reported that, across a sample of US firms and spanning the period from 1975 to 1994, a very similar 17% of new processes that could not have been developed without substantial delay in the absence of academic research and/or were developed with substantial aid from recent academic research.

The estimated average **value of cost savings from processes developed or introduced over the last three years** was DKK 490 000 per firm per year, or DKK 23.5 million per year in total across the sample (N=48). Researchers reported a higher average value of cost savings from processes developed or introduced over the last three years at DKK 964 000 per firm per year, and innovating firms a higher average DKK 522 000 per firm per year.

If 19% of these depended on academic research (Question 32), then the value of academic research to process savings was approximately DKK 94 000 per firm per year (DKK 4.5 million per year in total across the sample).

Respondents estimated **the average time lag between academic research and the first introduction of new products or processes** at 2.8 years (N=59). Reflecting closer participation in the underlying research and development, research respondents suggested an average lag of 3.7 years and incubator firms 4.1 years.

Mansfield (1998, p775) found that, across a sample of US firms and spanning the period from 1975 to 1994, average reported lags ranged from 2.4 years to more than 10 years with industry means between 5.1 years and 7 years. Given our focus on knowledge-based SMEs that build their business around innovation, these numbers accord reasonably well.

Respondents suggested that **it would have taken an average of 2.2 years longer to develop or introduce the new products or processes in the absence of contributing academic research** (N=50). Research respondents estimated a longer 3.4 years delay, incubator firms 2.7 years, and innovating firms 2.3 years.

For new products, on average annual sales of DKK 130 million, a 2.2 years delay would cost around DKK 36 million per firm in lost sales (DKK 3.2 billion in total across the sample). For new processes, a 2.2 years delay would cost around DKK 210 000 per firm in lost savings (DKK 10 million per year in total across the sample).

While no more than indicative, these responses suggest that academic research is of considerable value to firms, access to it is important and access barriers and delays are costly.

Comments from questionnaire respondents

At the end of the survey, respondents were asked if they wanted to make any general comments about research information access issues. Their responses included:

- When I worked at the University access to research articles was very easy. Now (in a private company) it is both difficult and expensive, and due to budget-cuts much information search is abandoned.
- It would be a great help for small start-up companies like ours, if there were free access to international as well as Danish academic research papers, without one having to visit the local research library with a subscription to the paper in question.
- The academic research is extremely valuable for building new areas of business, and enhancing existing areas of profitability – both in production, delivery and internally.
- For small companies it is very important to have tight personal contact to academics and scientists, who can transfer their results and conclusions to our development projects, as we have little time to digest the literature directly.
- All ideas came from studies around 1990. Since then they have been refined through different development stages until our company was incorporated in order to carry the first demonstrations through.

- Academic research is essential to developing. We are completely dependent on it.
- When we wish to introduce new technology it is important that all related and relevant information is easily available in order not to lose time or money in repeating activities all ready done.
- It is essential to have access to scientific information if you are a small research based company. If not, we could not do what we do and would have to give up to much larger competitors. The research libraries are so important.

The interviews

Interviews were conducted with three groups: (i) incubator firms that participated in Denmark's national innovative incubators scheme 'Innovationsmiljøerne'; (ii) non-incubator firms with contacts supplied by The Danish Agency for Science, Technology and Innovation; and (iii) survey respondents who offered follow-up interviews. Interviews were conducted during September and November 2010, and there were a total of 23 interviews conducted (13 with incubator firms and 10 with non-incubator firms).

The following comments summarise interview responses. Unless they appear in quotation marks, these 'comments' are paraphrased from respondents' answers recorded in interview notes in such a way as to represent what was said as faithfully and accurately as possible while ensuring anonymity. The full transcript of interview and notes cannot be released for reasons of confidentiality.

Incubator firms

Incubator firms saw access to patents, research articles, legislative and regulatory information as most important, some also mentioned the importance of scientific and technical standards and market information. Comments included:

- Access to research articles is important. The core business of the company is based on this kind of knowledge.
- Patents are extremely important. It is critical to track competitors' products and to see what developments have been made across the industry. We do this largely by looking at patent filings and pay a company to keep us up-to-date on this.
- We have a number of new products in development, building upon established principles. They are developed using patents rather than academic research. No R&D [*in this field*] is possible without access to patents.
- Legislative and regulatory information is extremely important. We are aiming at the European market and need to keep up with all legislative developments: we are governed by standards and regulations.

Accessibility issues were divided between: (i) reports of relatively easy access, but concerns over affordability; and (ii) reports of access difficulties and/or the workarounds they use to gain access. Comments included:

- Research articles are fairly difficult. We use the web to get access that way, but do not know what we are missing.
- At least 75% of the research articles needed in the last 12 months have been difficult to access. The difficulty is accessing the full-text. We generally discover articles through 'x' or reference lists in other articles, but then cannot access the full-text online.
- Patents are very easy. We use professionals, but they are expensive. We would love to know about free sources for this information.
- Patents are very difficult. They are fairly easy to locate, but not to access because there is a cost to this, either as a one-off thing or a subscription is required.
- Patents are both very easy and fairly difficult. It is easy to search for patents, but the bureaucratic process of getting them is hard. Universities get the patent, but to get hold of it a deal must be done with the university. It is difficult to 'get them out' into the industry.
- Legislative and regulatory information is fairly difficult. Finding the 'cold facts' may not be difficult, but getting the 'real view' is. It can be difficult for a small company to understand when a government sets out a new 'norm'.
- Legislative and regulatory information is very important, and it is important that this information is provided in forms that are easily understood and used by small firms who do not have the experts that large companies have to help them understand the implications of regulatory information.
- Market survey research is fairly difficult, and there is quite a cost to accessing this information as well.
- Market reports on sectors/products are very difficult to find and to access, largely because they are so expensive. We do access some material like this, but do it by asking investors and friends who may already have bought the information to let us see it.

Workarounds included:

- The company has a very close relationship with the University and has access to its library holdings as part of a business arrangement whereby the company pays the University rent for space and part of that deal is for access to the library's on-line services.
- Research articles are very easy to access, because the company works with post-graduates and post-doctorates in the University and these people can get access.
- It is easy to get to the abstract of an article, but very difficult to get to the full-text. If an article is needed, we use the nearest university library (for which we do not have to pay), but this is an hour's drive away and we cannot have online access.

We can pay for articles from publishers' websites, and sometimes do, but this is an expensive option for small companies.

- Research articles are very difficult. Locating and accessing the abstract is not difficult, but accessing the full-text involves a cost. The company does not pay to view articles... it is simply too expensive. Our workaround is to obtain articles through researcher colleagues and friends who work in universities and research institutes.
- We always have trouble accessing the articles we need unless they are in OA journals or PMC [PubMed Central]. We use the local university library through a network of friendly researchers and collaborators, and try to use different researchers each time, but inevitably have to keep going back to people at intervals – and I 'feel bad' about this: it is a nuisance to them.
- Sometimes I have difficulty getting access to the full-text of articles. When it is important to get access I ask a university student to get the article for me.
- Author's institutional websites are used several times a year. The company's personnel know everyone who works in the field and they are in contact with most of them from time to time.
- We do buy some articles, but we have a big delay in getting hold of some articles. A delay definitely impacts on our work. In some cases we may not even start a project because we cannot get the information – some projects might get delayed by a month or so. It all costs money and has implications.

Asked what they would like to have improved access to, the same priorities and issues arose – with **calls for improved access to research articles, patents, legislative/regulatory and market information, and discussion of the key issue of affordability**, especially for small start-up firms with highly constrained budgets. Comments included:

- If access to any of these types of information could be improved it would *definitely* be to research articles. Access to these is "a really, really major problem. All companies like ours face it. Getting access to one paper through a contact is great, but it usually leads to others that we need and then we are faced with paying for access or going without. The core business of the company is based on this kind of knowledge, but access to scientific information is so difficult".
- If access could be improved to any of those types of information it would be to research articles and conference papers/proceedings. We can find articles, but cannot get at the full-text very easily.
- If access could be improved to any of these, it would be to patents. This is solely because of the cost. Finding patents is not too difficult, but getting access to them is expensive.
- Easier access to standards and to legislative information would be a great benefit. If it were possible to more easily search for, locate and access these it would be great. We want to be sure we have found everything.

- If access could be improved, it would be to product/process specific information. We want market information and if this were easily available, preferably free of charge, it would help. Innovation centres around the world publish this type of information, but it is very expensive to buy good, detailed reports. There are cheaper ones, but they are not so specific and, therefore, less useful.

On the **value of access to research and technical information**, incubator firms realised the importance to them. One told the following story:

We have developed a prototype which will be on the market fairly soon. This could not have been developed without access to the scientific literature, but this literature is so hard to get hold of. Access problems have caused a delay in product development that was almost catastrophic. We took out a patent, which ran into problems that could have been addressed had we had access to one particular scientific paper while drawing up the patent information. We did not, so filed the patent application without this additional information. As a result, the patent was delayed while we had to go back and include certain things that emanated from that article. In the meantime, new investors, who we had lined up, would not come on board until the patent was successfully filed. There was a two-month hold-up, and we only filed the patent just within the investors' deadline for signing up with the company. It would otherwise have failed through lack of investment.

This example highlights what is, perhaps, the key issue. Of course, one could say that they should have paid the pay-per-view fee for this article, as the costs associated with not accessing it were far greater than the cost of access. Information is an “experience good” (*i.e.* you cannot know its value until after you have consumed it). But, perhaps, the real issue is access to the literature, not to particular articles. Many smaller firms do not have sufficient access to the journal literature to enable them to effectively monitor the literature, and they miss articles because they do not know about them. Of course, one could say that they should find a way to monitor the literature, but this would involve a relatively high cost, and most SMEs, especially the younger ones, have limited resources.

Non-incubator firms

Non-incubator firms had similar priorities, **seeing access to research articles, legislative/regulatory and patent information as most important**, others also mentioned the importance of scientific and technical standards and market information. Comments included:

- The company's innovation activity is highly dependent upon access to scientific information. It is a basic tool for development.
- It is possible to get research articles from university libraries, but it is very difficult. It is a last resort for us: it is difficult and quite expensive.
- It is very difficult to access scientific journals because most of them are pay-per-view (PPV). We need to be very focused in not spending too much money downloading papers that are not relevant.
- Besides journals, we use the ‘x’ patent database a lot. It is expensive, but we have some kind of access no matter how many we download. It is very important for us.

- All the patent information we use is from foreign sources. It is easy to get US patents, but very difficult to get Japanese and German ones. These are the three places where patents that we need come up.
- The company needs access to current and pipeline developments, and needs to sign up to a number of different databases and other services to enable searching of both basic and clinical, pharmaceutical and regulatory information.

Accessibility issues were similarly **divided between: (i) reports of relatively easy access, but concerns over affordability; and (ii) reports of access difficulties and/or the workarounds they use to gain access.** Comments included:

- The problem is not locating information: it is accessing it. Access can always be had if one is prepared to pay, but that is not possible for the amount of information we need. It is too expensive.
- Finding out whether it is available is one of the problems. Even if we find the articles we need, we come up against pay barriers. Sometime we pay for the article, but sometimes it is not possible.
- We need scientific papers from not just one application area, but from many – some basic science areas and some specialised ones. We cannot subscribe, because there are too many journals that the papers come from.

Workarounds included:

- We are trying to develop without access to the literature, though the company has access to a university where it is sponsoring a doctoral student. This person can access information for the company.
- Based on a scientific background in the University, we use contacts to download a lot of papers for us. My [post-graduate] students are my link to the literature...
- We use 'x' University and others a lot. They are very helpful and there are good connections between us. If we ask for something they do very well, and we do not have to pay unless they have to pay for the item themselves.
- We use journal articles a lot. Mostly, access is through the universities or from the web. We have collaborations with people in universities. The libraries cannot be used directly by company employees, but articles are obtained through the people in the universities.

Asked to what they would like to have improved access, the same priorities and issues arose – with **calls for improved access** to research articles, patents, legislative/regulatory and market information, **and discussion of affordability**, especially for small start-up firms with highly constrained budgets. Comments included:

- We definitely want improved access to research articles and conference papers.

- If the company could have better access to anything, it would be to market information. It is so difficult to find.
- Other types of information that are very important include market information, because so far we have been doing business in Denmark but we have plans to address new markets.
- Clinical guidelines and regulatory information are very important, as well as basic science.
- Open access would be a big help. An open database of literature would be a great thing and the user interface should be as easy and intuitive as possible... It would be really great if all the links to free articles could be on one site, not interspersed with commercial links. That would be very helpful.
- What I am missing the most since I left the university environment is the same sort of access to research articles that we had as students and while I was doing my PhD. That was a very easy and satisfying way of accessing research articles. So for me, if the Ministry could do something it would be to provide some type of access to a number of free articles or an easier, cheaper, way of doing it than how I can do it today, because paying for accessing all these articles today is very expensive.

On the *value of access to research and technical information*, non-incubator firms realised the importance to them. They told the following stories:

- I would say that until now we have been lucky in not missing too much. That is why we spend so much time searching commercial databases when we are doing IPR [intellectual property right] protection. I am so afraid that some scientist may have the same idea as we have had, from a commercial point of view, and not filed patents, but published it at some American conference or something. That is why we are paying for access to articles, so that we do not miss any of these things.
- When we carry out our activities, we run into problems [from lack of access to the literature]. For example, very recently another party tried to patent a way of making a type of 'x' that I am very interested in. It occurred to me that the way he was doing this was not very novel [and should not be patented], but as I did not have access to scientific material about this, documenting the method he was trying to patent, it became very difficult for me to make the case. I had to rely on what other people who had some access could find out. So in terms of our activities, we have serious problems in that regard. We have no links with a university, so cannot get material that way.
- One example of the impact of not having access to the right information was very costly for the company. The company had used a particular type of 'x' which had undergone a ten-year test/assessment. When the results came out they showed that the material was not suitable. The company missed this and used the 'x' product in their work, and had a lot of subsequent problems with insurance, etc. It was very expensive.

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- The company experienced one instance where lack of access was quite expensive. The company had to do the research itself because the published article reporting the original research was inaccessible... It took several months and thus had a cost in terms of effort and lost time. "It cost us a lot of money to do this." Small companies would find access to university libraries really useful. Our researchers would be happy to go in person, although electronic access would be even better. But if the library could be used, without payment, to access even the search services, it would be good. The company has no subscriptions because articles are spread out across a large number of journals and it would be too expensive to buy journals just in case relevant articles appear.

These examples illustrate the access difficulties and problems faced by small innovative firms in Denmark, and provide leads as to what would be valued by them in terms of practical support.

Small and medium sized enterprises (SMEs) form a major part of many economies and they play a key role in innovation. Consequently, SME access to and use of research findings is important, not only for firm-level performance but also for the overall performance of national economies.

Conclusions

Comparing responses on the importance and ease of access to research information, suggests that the **things that are both important and difficult to access include research articles and market survey research and reports** (and, for some firms, patents).

Forty-eight per cent rated *research articles* as very or extremely important, and among those in research roles a higher 64% did so. Thirty-eight per cent said they always or frequently had difficulty getting the *research articles* they needed, and a further 41% said they sometimes had difficulties.

This and past studies show the importance of publicly funded and academic research for private sector innovation and firm performance, as well as highlighting the centrality of information exchange and publication in knowledge transfer.

An average of 27% of the products developed or introduced during the last three years would have been delayed or abandoned without access to academic research. Research respondents reported a higher average of 38% and incubator firms reported a still higher average 42% – attesting to the importance of academic research for innovative firms. Similarly, an average of 19% of the processes developed or introduced over the last three years would have been delayed or abandoned without access to academic research. Researchers reported a higher average 34% and incubator firms 32%. The value of academic research to sales was around DKK 16 million per firm per year, and the value to cost savings DKK 490 000 per firm per year.

It would have taken an average of 2.2 years longer to develop or introduce the new products or processes in the absence of contributing academic research. For new products, a 2.2 years delay would cost around DKK 36 million per firm in lost sales, and for new processes it would cost around DKK 211 000 per firm in lost savings.

The firms interviewed saw access to research articles and patent information as the most important sources of information; some also mentioned scientific and technical standards and market information. Accessibility issues were divided between: (i) reports of relatively easy access, but concerns over affordability; and (ii) reports of access difficulties and/or the workarounds they use to gain access.

Asked to what they would like to have improved access, the same priorities and issues arose – with **calls for improved access to research articles, patent, legislative/regulatory and market information, and discussion of the key issue of affordability,** especially for small start-up firms with highly constrained budgets.

An important point made by interviewees is that the subscription model does not work for them because the content they need is spread widely across many titles. The world

they operate in is not organised into disciplines and their access needs span a wide range of basic and applied research across disciplinary boundaries. The pay-per-view model can provide access to particular articles, at a cost. But many small firms find the cost too high. However, the pay-per-view model cannot provide the breadth of access to the literature necessary for them to scan widely and be aware of what of relevance is available, and subscription to mainstream abstracting and indexing services is too expensive for small firms.

What is needed is both sufficient breadth of access for them to be able to scan widely and be aware of developments and access to specific content. Effectively, the value of access has both specific and network dimensions. Hence, neither of the mainstream toll access publishing models entirely meets their needs. The widespread use of Open Access alternatives appears a natural response.

Recommendations

Options for improving access include: (i) addressing information literacy and improving the capacity of SMEs to navigate the information landscape; (ii) addressing accessibility and affordability of access for SMEs; and (iii) responding to the expressed concerns and wishes.

Information literacy

It is clear that **SMEs sometimes lack the higher-level information literacy skills** that would help them to more effectively navigate the information landscape, to discover and access the information they need.

That generic search engines (*e.g.* Google) are so overwhelmingly used for search, discovery and access, and the second most commonly cited difficulty encountered was “I searched for the article online, but could not find the article” suggest that there may be scope to further develop information literacy skills and/or provide support.

That there is a slowly growing corpus of Open Access literature is not well-known to most SMEs. Many are not familiar with the term Open Access and do not understand its importance or the usefulness to their needs. Their information literacy is sometimes limited, and in respect to academic information it is in most cases certainly limited to the ‘traditional’ subscription-based scenarios of searching, retrieving and accessing the information they need.

Information sharing and **raising awareness and skills through meetings, workshops and training** sessions might provide one useful avenue for developing information literacy skills, but those operating in SMEs are often highly time constrained.³ Another option might be to offer **a targeted ‘reference librarian’ style service** that could provide a one-stop-shop point of contact for knowledge-based SMEs.

Accessibility and affordability

This and other studies reveal the focus of SME information access needs and the areas in which they experience difficulties. **There is a need for improved access to research articles, patent, legislative/regulatory and market information. And it is clear that the issue is one of both accessibility and affordability.**

³ Organizations such as Det Informationsvidenskabelige Akademi (IVA) might provide expertise in this area.

Addressing affordability rests on reducing the direct monetary and time penalty costs involved in access the information needed. This could be through a range of options, including:

- **Consortial purchasing** – exploring the possibility of a national or possibly regional Scandinavian purchasing and licensing scheme;
- **Extended licensing** – exploring the possibility of extending existing university and other consortial purchasing and licensing to more easily include SME access through research libraries;
- **Specific funding** – exploring the possibility of establishing a funding program to support SME access; and
- **Supporting Open Access** – by encouraging and, perhaps, mandating Open Access to publicly funded research findings in the form of both research articles and other publications and scientific and research data.

However, these options carry very different costs for government and others. For example, the first three would require a centralisation of funding and/or additional funding, whereas the last is free to government, researchers and SMEs. The last option may also have wider impacts (*e.g.* the possibility, through opening up Danish research to the world, of it being built upon by innovators elsewhere, with the possibility of value being captured in Denmark through new collaborations with Danish universities and possibly new spin-offs).

An SME wish list

A number of interviewees and survey respondents made specific requests and suggestions, so we leave the last word to them.

- It is essential to have access to scientific information if you are a small research-based company. If not, we could not do what we do and would have to give up to much larger competitors. The research libraries are so important.
- Patents are very easy. We use professionals, but they are expensive. We would love to know about free sources for this information.
- Legislative and regulatory information is very important, and it is important that this information is provided in forms that are easily understood and used by small firms who do not have the experts that large companies have to help them understand the implications of regulatory information.
- For me, if the Ministry could do something it would be to provide some type of access to a number of free articles or an easier, cheaper, way of doing it than how I can do it today, because paying for accessing all these articles today is very expensive.
- Open access would be a big help. An open database of literature would be a great thing and the user interface should be as easy and intuitive as possible... It would be really great if all the links to free articles could be on one site, not interspersed with commercial links. That would be very helpful.

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There is a need for improved access to research articles, patents, legislative/regulatory and market information.

Small and medium sized enterprises (SMEs) form a major part of many economies and play a key role in innovation. Consequently, SME access to and use of research findings is important. This study examines levels of access to and use of research and technical information by knowledge-based SMEs in Denmark.

Research articles, patent information, scientific and technical standards, technical and market information were seen as the most important information sources for SMEs. 55% reported difficulties accessing research articles. More than two-thirds reported having difficulties accessing market survey research and reports and Doctoral or Masters theses and 62% reported difficulties accessing technical reports from government agencies.

Access barriers and delays involve costs. It would have taken an average of 2.2 years longer to develop or introduce the new products in the absence of contributing academic research. For new products, a 2.2 years delay would cost around DKK 36 million (EUR 4.8 million) per firm in lost sales.

The survey concludes that there is a need for improved access to research articles, patent, legislative/regulatory and market information. It is clear that the issue is one of both accessibility and affordability.

Der er brug for lettere og billigere adgang til forskningsartikler, patenter, love og administrative bestemmelser samt markedsinformation.

Små og mellemstore virksomheder udgør en væsentlig del af samfundsøkonomien og har stor betydning for innovation og vækst. Det er derfor vigtigt, at de har adgang til og gør brug af forskningsresultater. Denne rapport undersøger behov og brug af videnskabelig og teknisk information blandt videnbaserede små og mellemstore virksomheder i Danmark.

Forskningsartikler, patentinformation, videnskabelige og tekniske standarder, teknisk information og markedsinformation betragtes som de vigtigste informationskilder for små og mellemstore virksomheder. 55% angiver, at de har vanskeligt ved at få adgang til forskningsartikler. Mere end to tredjedele angiver, at de har vanskeligt ved at få adgang til markedsundersøgelser, rapporter, specialeopgaver eller afhandlinger, mens 62% fortæller, at de har vanskeligt ved at få adgang til tekniske rapporter fra statslige instanser.

Adgangsbarrierer og forsinkelser koster penge. Det ville i gennemsnit have taget 2,2 år længere at udvikle eller introducere nye produkter uden brug af den akademiske forskning. For nye produkter vil en forsinkelse på 2,2 år medføre, at et firma gennemsnitligt mister omkring 36 mio. kr. i omsætning.

Undersøgelsen konkluderer, at der er brug for lettere og billigere adgang til forskningsartikler, patenter, love og administrative bestemmelser samt markedsinformation.