SMEs and the new role of academic research in four Nordic countries

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Sammanfattning

Bakgrund

Enligt OECD spelar små och medelstora företag, och då speciellt teknikbaserade företag, en definitiv och allt mer framträdande roll i innovationssystem (OECD, 1999; 2002). Förutom att bidra direkt till ekonomisk tillväxt genom utvecklandet av produkter och servicefunktioner, stimulerar också små och medelstora teknikbaserade företag en innovativ kultur, där investeringar i kompetens speciellt premieras. Det har t.o.m. föreslagits att denna typ av företag kan utgöra en god metafor för hur relativt små länder framgångsrikt kan ta sig fram i en alltmer globaliserad värld. Metaforen syftar specifikt på den roll som små och medelstora företag spelar vis-a-vis större företag i en globaliserad ekonomi, och till deras speciella förutsättningar och överlevandsstrategier. Trots att de små och medelstora företagens roll i nationella ekonomier länge ansetts viktig, så är förutsättningarna för deras tillväxt på många sätt alltjämt otillräckliga, och deras innovationskapacitet begränsad.

Åtminstone sedan ett årtionde tillbaka, och i takt med en global trend, har de nordiska länderna enskilt satsat på att utveckla policymodeller för att stödja sina respektive innovationssystem. Samarbeten mellan högskola och näringsliv såväl som kommersialisering av vetenskapliga resultat har kommit att spela ett viktig roll i dessa modeller. Resultaten har hittills varit lovande. EUs statistiska rapport år 2000 rörande vetenskap, teknologi och innovation visar att tre nordiska länder, Danmark, Finland och Sverige, ligger över EU-genomsnittet (3,5%) för näringslivsinvesteringar i innovation (EU, 2000). Norge ligger alltjämt under denna nivå, trots uttalade politiska ambitioner att förändra situationen. Investeringarnas omfattning motsvaras dessvärre inte alltid av ökning i innovation. Faktum är att från ett globalt perspektiv verkar inte Europas FoU-investeringar leda till goda innovationseffekter, och flera av de nordiska länderna uppfattar sig ha avsevärda problem i detta avseende.

Det har länge varit känt att de små och medelstora företagens innovativa och entreprenöriella förmågor kan ha avsevärda positiva effekter på kommersialiseringen av nya teknologier.Kunskapssamhället har inneburit att allt fler företag börjar se konkurrensfördelar kopplade till förmågan att identifiera och utveckla strategiskt

viktiga kompetenser, och samtidigt upprätthålla en bred kunskapsbas genom att t.ex. ingå strategiska allienser med andra företag och kunskapsproducenter. Genom sin roll i utvecklande av vetenskaplig och teknisk kunskap och expertis, utgör universiteten en viktig aktör i denna process. Forskning på små och medelstora företag visar dessutom att program för att stödja dessa företags tillgång till teknologi och kunskap, t.ex. genom finansiellt stöd och nätverksorganisationer har begränsad effekt, eftersom de små och medelstora företagens uppfattning av nyttan i nya teknologier och nya kunskap ofta är kopplad till deras närhet till kunskapsproducenten (läs här högskolan) (Woolgar et al., 1998; ESTA, 1997). Detta tillsammans med den snabba teknikutvecklingen har lett till slutsatsen att det finns ett behov av att skapa mer stabila och långsiktiga stödsystem för innovation, samt att utvärdera huruvida existerande stöd, t.ex. teknikparker, är tillräckliga (Iversen, 2001).

De nordiska länderna har tagit en rad initiativ för att öka dynamiken i denna sektor. På en generell nivå har försök gjorts att stimulera flödet av kapital och kunskap genom skapandet av olika samarbetsformer mellan små och medelstora företag och kunskapsproducenter, speciellt då i syfte attgenom sådana artnerskap öka högskolornas kommersialieringstakt. Mer specifikt uppehåller sig dessa reformer kring tre områden: Förändring av de regelverk som styr intellektuellt ägande och exploatering av kunskap i offentliga forskningsorganisationer, utvecklande av infrastruktur för kommersialisering av offentligt finansierad forskning, samt reform av de offentliga aktörerna inbegripna i forskning, t.ex. högskolan.

Syfte med studien

Föreliggande projekt grundas på en studie av fyra länder, Danmark, Sverige, Norge och Finland, där följande undersökningssyften har utgjort fokus:

1. Att undersöka policies och institutioner (formella såväl som informella) som syftar till att stödja kommersialisering av akademisk forskning och/eller kunskapsutbyte mellan små och medelstora företag och högskola, samt
2. att därvid utröna vilka som är de viktigaste möjliggörande faktorerna resp. hinder för sådana processer i de studerade länderna.

Undersökningen har adresserat dessa syften genom att genomföra en omfattande översikt och analys av policies, policytexter samt forskningslitteratur rörande Danmark, Sverige, Norge och Finland, samt andra länder. Denna studie har

kompletterats med ett urval av fallstudier av små och medelstora företag i vart och ett av de studerade länderna.

Litteraturöversikt

Det saknas inte forskning på små och medelstora företag. En genomgång av litteraturen ger vid handen att en explosion av detta forskningsfält har skett under de fem senaste åren, med flera nya tidskrifter där artiklar enbart om denna typ av företag publiceras. Intresset av också ökat bland offentliga beslutsfattare och analytiker; OECD publicerar nu t.ex. en skrift vars syfte är att undersöka 'state-of-the-art' inom detta område i de Europeiska länderna (OECD, 2002). EU har dessutom ett välutvecklat system för stöd av små och medelstora företag kopplat till sina forskningsprogram, såväl som flera nationella program för sådant stöd. Några resultat från literaturen är värda att ta fasta på:

- Små och medelstora företag i glesområden tenderar att vara mer innovativa än små och medelstora företag i städerna, dock tenderar dessa att använda externa kunskapskällor i mindre utsträckning än de stadsbaserade företagen (Keeble and Walker, 1993; Keeble, 1990; Oakey, 1991).
- Små och medelstora företag har i allmänhet stora svårigheter när det gäler att kommersialisera nya produkter (Pratten, 1991).
- Regionen och den lokala miljön är viktigare för små och medelstora företag än för större företag (Asheim, 2002; Tödtling, 2002).
- Investeringar i FoU utgör ingen tillförlitlig indikator på innovationbenägenhet för små och medelstora företag.
- De små och medelstora företagens uppfattning om nyttan av ett nytt teknologisk koncept är ofta beroende av det sociala avståndet mellan företaget och källan för det aktuella upptäckten (t.ex. universitetet) (Woolgar et al., 1998; ESTA, 1997).
- Denna sektor är mycket heterogen, vilket ofta leder till motsägelsefulla resultat vid jämförelse av innovationsnivåer mellan små och medelstora företag och större företag (Kaufmann och Tödtling, 2002; Woolgar et al., 1998; Acs och Audretsch, 1990; Pavitt et al., 1987).
- Framgångsrik kommersialisering av akademisk forskning är beroende av ett aktivt deltagande från de forskare som gjorde upptäckten i

kommersialiseringsprocessen (Siegel et al., 2003; Zucker et al., 1998; Audretsch och Stephan, 1996).

Policyförslag

Sammantaget visar huvudresultaten från föreligande studie att trots att existerande policyreformer har varit omfattande, så återstår ett antal viktiga problem att lösa. Dessutom måste det påpekas att vart och ett av länderna är unikt i termer av vilka av rekommendationerna som kan förväntas fungera, och dessa skillnader presenteras i detalj i huvudrapportens delstudier. I denna sammanfattning lägger vi tonvikten på generella, gemensamt relevanta interventioner, samt på de utmaningar som bäst adresseras på genom inter-nordiskt samarbete. Först och främst finns det ett antal övergripande utmaningar som återkommer i flera sammanhang. En av dessa är utmaningen att stimulera skapandet och utvecklandet av relevant humankapital, samt finansiella och institutionella resurser för dess överföring. En av de viktigare frågorna i detta avseende är att stimulera utvecklingen av en fungerande privat riskkapitalmarknad. Det finns också ett behov av att utveckla och diversifiera existerande policy för små och medelstora företag, i syfte att möta sektorns mångfald. Detta inbegriper bl.a. en uppdatering av komptenser inom de mer traditionella branscherna. Följande punkter framstår som speciellt viktiga för att utveckla komersialisering av kunskap i snittet mellan små och medelstora företag och högskola:

Utveckla det akademiska meriterings-systemet för att öka motivationen kommersialisera av kunskap.	Universitet och högskola bör utveckla det akademiska meriteringssystemet så att intresset ökas för forskare att engagera sig i kommersialisering av sin forskning. Nordiskt samarbete kan här hjälpa till att minska osäkerheten för enskilda institutioner genom reducera risken för att forskare flyttar till andra institutioner vid förändring i deras förutsättningar.
Utveckla stödstrukturer för projektifiering av akademiskt arbete.	Universitet och högskola måste ges eller tillåtas frigöra resurser för att skapa strukturer som underlättar projektbaserat arbete.
Öka humankapitalets mobilitet mellan	Regering och myndigheter, fackförbund

sektorerna.	samt näringsliv bör samarbeta för att stimulera mobilitet av humankapital mellan sektorer. Sådana initativ torde stödja kunskapsöverföring till såväl små och medelstora företag som näringslivet i stort.
Stimulera en entreprenörskultur på det nationella planet.	Flera länder har utvecklat mekanismer för att stimulera en entreprenörskultur i högskola och andra offentliga forsknings-verksamheter. Det finns ett behov av att utöka sådana initiativ till samhället som helhet. Exempel kan vara införande av informationsprogram om entreprenörskap som ger företagande en positiv framtoning och sprider kunskap om hur man startar affärsverksamheter.
Statligt stöd för utvecklandet av en kompetent riskkapitalmarknad i den privata sektorn.	Samtliga länder i föreliggande studie har relativt underutvecklade riskkapital-marknader, med små investeringar i de tidiga faserna av innovationsprocessen (sk. såddfinansiering). Visst statligt stöd kan krävas för att stimulera framväxten av den privata riskkapitalmarknaden.
Mer uppmärksamhet bör fästas vid alternativa kunskapskällor för små och medelstora företag, förutom universitet och högskola.	Nationella och regionala organisationer bör samarbeta med de små och medelstora företagens intresse-organisationer för att utveckla och förbättra kunskapsbasen för dessa företag. Mässor, nätverk mellan stora och små företag, branschtidskrifter, etc. utgör viktiga kunskapskällor för små och medelstora företag.
Universitet och högskola bör utveckla olika tper av modeller för kunskapsöverföring till små och medelstora företag	Det faktum att social närhet utgör en viktig faktor i kunskapsöverföringen mellan små och medelstora företag och universitet/högskola, innebär att kunskapsöverföring till dessa företag bör differentieras. Tekniköverföring baserat på modeller från lantbruksuniversiteten torde vara en rimlig utgångspunkt för små och medelstora företag utan tidigare kontakter med universitet/högskola.

Executive Summary

Background

Small and medium-sized enterprises (SMEs) especially new technology-based firms play a distinctive and increasingly important role in innovation systems according to the OECD (cf. OECD 1999; 2002). Apart from their direct contribution to economic growth through the creation of goods and services, new technology based firms for instance instill a culture of innovation, encourage investment in skills. It has even been suggested by some authors that SMEs should be used as a metaphor for understanding how small countries can successfully navigate through the forces of globalization (Davenport and Bibby, 1999). This metaphor both points to the special situation faced by SMEs vis a vis larger companies in a globalizing economy and to their unique skills in finessing this situation. Despite the recognition of the importance of SMEs to national economies, the conditions for the creation and growth of SMEs remain far from optimal in most countries and the innovation capacities of most SMEs are still limited.

Over the last decade or so, Nordic countries in keeping with global trends have been individually developing policy frameworks for supporting the development of their respective national innovation systems. University-industry cooperation and the commercialization of academic research in particular have been assigned a central role in this policy effort. The results thus far are quite good. According to the European Union's report on key figures for science, technology and innovation for 2000 show that three Nordic countries are above the EU average (3.5%) for individual firm expenditure on innovation, Sweden, Finland and Denmark (EU, 2000). Norway remains well below this level despite repeated policy commitments to change this state of affairs. The level of investment in all cases is not however matched by a corresponding innovation pay off. In fact, seen from a global perspective Europe as a whole is not doing well in terms of getting high levels of innovation out of its investment in R&D and many Nordic countries feel themselves to have a particularly acute problem in this respect.

It has long been recognized that the innovative and entrepreneurial capabilities of the SME sector can make an important contribution to the commercialisation of emerging technologies. The advent of the knowledge economy has brought the

additional insight that more than ever competitive advantage in the industrial sector is directly connected to companies' capacity to identify their strategic capabilities and develop them while keeping a broad base of knowledge on tap through the use of strategic alliances with other companies and with knowledge providers. In their role as centres of expertise and originators of new technical knowledge, universities are vital contributors to this process. Additionally, existing research on SMEs shows that previous policies for assisting SMEs to access technology and knowledge through intermediate arrangements such as capital access schemes or liaison institutions are of limited utility since SME perception of the utility and exploitability of a new technology is often dependent on the social distance of the SME from the site of invention (the university) (Woolgar, et al. 1998; ESTA, 1997). This taken together with the rapid pace of technological development have led a new series of studies to conclude that there is a need to focus on long-term support systems and to evaluate whether existing support structures e.g. research parks are sufficient (Iversen 2001).

Nordic countries have taken a number of measures to increase the dynamism of the SME sector. At a general level efforts are directed at increasing the transfer of knowledge and capital by facilitating the formation of a variety of collaborative arrangements between SMEs and knowledge providers in general and in particular increasing the pace at which PROs commercialise the knowledge they produce. More specifically, the process of policy reform targets three areas of priority: the reform of the rules and laws governing ownership and exploitation of IP at public research organizations; the provision of infrastructure for the commercialisation of public R&D, and the reform of public providers of R&D.

Objectives

The project is a four country study which focuses on Sweden, Denmark, Norway and Finland. The main objectives of the study have been:

1. To examine the policies and institutions (formal and informal) designed to promote the commercialisation of academic research and/or knowledge exchange between SMEs and universities; and

2. To ascertain what are the main drivers and/or obstacles to the commercialization of academic research in the studied countries.

The above is achieved through an extensive review and analysis of the policies; studies and academic literature produced on the state of the art in Denmark, Norway, Finland and Sweden. This information is supplemented with a select number of case studies of SMEs in each of the studied countries.

Literature Overview

There is no shortage of research on small and medium sized enterprises. A perusal of the literature on the subject will reveal that there has been a veritable explosion of research in the area and several new journals have been established over the past five years that devote themselves exclusively to publishing academic research on SMEs. Likewise, there has been a great deal of policy interest; the OECD now produces a specific publication dedicated to examining the state of the art on SMEs in OECD countries (OECD, 2002). Further, the European Union has a fairly well developed system of support for SMEs attached to its research programmes as well as several national programmes for SME support.

- SMEs in rural areas tend to be more innovative than their urban counterparts although they are less likely to use external sources of knowledge (Keeble and Walker, 1993; Keeble, 1990; Oakey, 1991).
- SMEs face serious difficulties in commercializing new products (Pratten, 1991)
- The region and immediate local environment is more important to SMEs than to large firms (Asheim, 2002; Tödtling, 2002)
- Company expenditure on R&D is not a reliable indicator of innovativeness in SMEs
- SME perception of the utility and exploitability of a new technology is often dependent on the social distance of the SME from the site of invention (the university) (Woolgar, et al. 1998; ESTA, 1997)
- The SME sector is radically heterogeneous and this often leads to contradictory results when comparing the levels of innovativeness between SMEs and large firms, (Kaufmann and Tödtling, 2002; Woolgar, et al. 1998; Acs and Audretsch, 1990; Pavitt, et. al. 1987).
- Successful commercialization of academic research depends on the active participation of the researchers who were the original discoverers of the knowledge to be commercialized (Siegel, Waldman and Link, 2003; Zucker et al., 1998; Audretsch and Stephan, 1996)

Policy Conclusions

A summary review of the main findings of the study shows that while the existing and proposed policy reforms have been extensive, there remain a number of important gaps. There are important differences in what kinds of recommendations can work in the respective countries and the country studies provide ample detail on the particular situation in this respect. In this part of the report, we focus on a more general level and on challenges that may perhaps best be met through cooperation at the Nordic level. First and foremost, there is the continuing challenge at the general level to facilitate the continued development of the relevant human, financial and institutional resources. Among the more outstanding gaps is the need to improve public support for the growth and development of the private venture capital market. There is also the need to further develop and diversify existing SME policies in order to cater to the radical heterogenity of the sector. This includes the problem of updating the competence profile of SMEs in traditional sectors.

Develop the academic merit system so as to provide incentives for commercialisation	Universities need to develop the academic merit system in order to create incentives for individual academics to engage in commercialisation activities. Cooperation at the Nordic level may help to reduce the level of uncertainty for individual institutions and reduce the risk of staff migrating to other institutions.
Develop support structures for the growing projectification of academic work.	Universities have to devote resources to create effective support structures for the increasing projectification of academic work.

Increase the mobility of human capital between the university and business sectors	Governments, labor unions and private firms need to cooperate to develop schemes for promoting the mobility of human capital between sectors. This type of initiative would not only support the diffusion of knowledge to SMEs but to all sectors of the business community
Promote enterprise culture on a national level	Most countries have developed mechanisms and policies for promoting the development of an enterprise culture among PROs and universities. There is a need to extend this to the society as a whole. The introduction of public education programmes that give entrepreneurship a positive image and provide information about how to start a company may be an initial step
State support to assist in the development of a competent venture capital market	All country reports show a relatively underdeveloped private venture capital market and a scarcity of investment for early stage development. Some state intervention is necessary here to help to develop the private market
More attention needs to be paid to the other sources of knowledge that SMEs utilise apart from the PRO sector	National and regional organisations should work with SME lobby organisations to develop and improve other sources of knowledge utilised by SMEs. Trade fairs, small-big firm networks, trade magazines, etc. are all significant sources of knowledge to SMEs
PROs should develop diversified types of knowledge delivery systems for SMEs	The fact that social proximity is a significant factor in determining SME-PRO interaction suggests that knowledge transfer to SMEs should be differentiated. Extension services modelled after the agricultural university approach may be one potential solution for SMEs with no history of PRO interaction

SMEs and the new role of academic research in four Nordic countries

Introduction

The last ten years have seen an unprecedented shift in the research policies of Nordic countries towards promoting interaction between the business and the public research sectors. The fact that this trend is reproduced either in part or in its entirety in all OECD countries is testimony to the growing convergence in the policy area already observed by a number of commentators (Lemola, 2000; OECD, 2001). In this report, the focus will be a comparative overview of one sub area of this policy domain, i.e. the mechanisms used to promote interaction between small and medium sized enterprises (hereafter SMEs) and public research organisations (from hereon PROs). The empirical referents of this study are the SME-PRO interaction policy mechanisms available in four Nordic states: Finland, Norway, Denmark and Sweden respectively.

The overall report is comprised of five chapters including the present. This chapter is subdivided into five sections in total. This, the first section will provide general introductory information including the main objectives of the study. The second section is a review of the literature relevant to this area. This review will be used as a sounding board for reflecting on the collected findings of the country reports as well as serve as a source of additional data from other countries. The third section will be an overview of the main trends in the policies of the four countries under study and the fourth will analyse the weaknesses and strengths of these policies in their respective contexts. The final section will provide some concluding remarks and a summary of the policy conclusions of the respective country reports.

Objectives

The objective of the overall study has been to identify the state of the art with respect to the commercialisation of academic research in four Nordic countries. This has been pursued by focusing on two main tasks:

1. Examining policies and institutions (formal and informal) designed to promote the commercialisation of academic research and/or knowledge exchange between SMEs and universities; and

2. Ascertaining what are the main drivers and/or obstacles to the commercialization of academic research in the studied countries.

The above coupling between SMEs and the commercialisation of academic research is justified by the fact that the innovative and entrepreneurial capabilities of the SME sector have been argued to be an important contribution to the commercialisation of emerging technologies.

Limitations of the study

This study is intended to be a review of extant research in the area, little new empirical research was conducted for this report save for the 16 case studies (4 in each country) of specific firms. The case studies have been used first and foremost to get a quick overview of how SMEs themselves perceive the existing policy mechanisms and to shed light on whether they perceive PROs to be important sources of R&D. The sample size is small but it has not been used as representative of the universal set of SMEs rather as a source of thick information about specific issues. This information is supplemented with other studies both of empirical and theoretical

character so that we were able to ascertain whether the information obtained in the interviews concurs broadly with extant knowledge.

In studying the four countries a number of methodological difficulties were encountered which we believe that it is important to state here since they are of relevance to future studies. The first is the assumption that the four Nordic countries are sufficiently similar that comparisons among them are worthwhile for benchmarking purposes. If one considers that apart from the fact that all the studied countries have some form of social democratic ideology and a common history, there are several differences with direct import for the issue under study here. For the first, although Finland and Norway are currently pursuing successful policies for economic diversification, both countries remain heavily dependent on one industry or commodity. Denmark and Sweden have more heterogeneous economies but are radically different. The Swedish economy is larger and for the most part dominated by a small number of large often international firms and the Danish economy is comprised of a large number of small-medium sized firms in different sectors ranging from agriculture to services with the emphasis on services. If we regard economic structure as an important limiting or enabling factor for what government policy measures can achieve, then one would conclude that it is not clear that these countries would necessarily all be focusing on promoting SMEs in the same way.

Further, when one focuses on SMEs themselves, the difficulties in comparison multiply. The EU definition of an SME is a firm with an employee count of no more than 250. Within this range three kinds of firms are delimited, micro enterprises with no more than 10 employees, small firms with a maximum of 50 employees and medium sized companies with 250 employees. While this standardisation has been very helpful in terms of introducing some consistency in understanding what firms go

under the rubric SME, it obscures the fact that firm size says nothing about the impact of the firm on the economy in which it is located neither in national nor local terms. In the Nordic case, a company with 100 employees will have very different potential for impact on the different countries' economies. For example, such a company may be very influential in Norway or even Denmark but have little or no impact in Sweden.

On the issue of main importance to this report, i.e. interaction between SMEs and public research organisations, there are also some important differences worthy of mention. All the countries have a broad mix of public research organisations ranging from universities and polytechnics to more applied and industrial research institutes. In addition they all have a part of the public research structure which is known as the sector organisations. These are organisations that conduct research in order to support policymaking activities in a given sector. Further examination of this common landscape reveal important differences as one moves from country to country. Sweden is the outlier in this case with a heavy dependence on universities for its public research needs and a small and fairly weak institute sector. Norway, Denmark and Finland have much more in common here in that there is a fairly large and thriving institute sector in all these countries. Finland is perhaps leading in this regard with the VTT – a 3000 employee strong research institute covering almost all fields- being one of the largest research institutes in Europe and certainly the largest in the Nordic region. Later sections of this chapter, the literature review and the four country studies will show that the type of PRO is an influential determining factor for some types of SMEs decision to collaborate or not. Thus, the nature of the structure of the PRO sector in the different countries is an important factor for consideration

when one is evaluating the potential success/failure of specific measures to promote SME-PRO interaction.

Finally, during the period of this review (2002-2003), most of the countries under study have been in the process of making new policy in areas that are directly or indirectly part of the brief of this study. For instance, Norway has only recently implemented important new legislation which changes the basis for ownership of intellectual property at universities and thereby the basis for commercialization. The upcoming Finnish election is expected to lead to some change in the policy for the commercialisation of public research and Denmark is now introducing reform of the university sector and is expected to produce its policy for university-industry interaction in March 2003. Sweden has also been in the process of considering reform for several years and recently Vinnova has put forward a proposition to the government that appears to have the support of most universities. No decision has been made up to the time of this report but the proposition states that Sweden should keep the professor exception rule and that universities should be assisted with the necessary resources to provide support for commercialisation.

While, the report includes as much updated material as has been available, it is merely of an informational character since these policies are naturally too new to evaluate their impact. This also holds true for some of the more recent reforms particularly with respect to promoting cultural changes in universities for example. Even though many of these policies are at least five years old, it is still too early to assess how they will eventually impact on the SME sector for a variety of other reasons that will be explicated later.

Literature Overview

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Given the former, it is surprising that extant academic research provides little support for those in the policy sector wishing to develop new approaches to stimulating growth and innovation in SMEs. Likewise the performance of existing policies both on the nation state and regional levels is mixed with a few high performing areas or sectors and a vast majority of less successful ventures. A review of the literature will reveal that there are about four to five main themes that dominate the attention of academics interested in the problem of innovation in SMEs and by extension SME-PRO interaction. These four themes may be translated in four questions:

1. What factors determine SME-PRO interaction and how can they be encouraged to develop?
2. How do SMEs innovate?
3. How do SMEs access new knowledge and who are the preferred providers?
4. What types of policy instruments are most effective for promoting SMEs?

Keeping one's focus on these questions, it is surprising how little can be gleaned that can be fed directly into policy. In the following paragraphs, we will summarise the main findings of the literature focused on the questions outlined above. Although this literature is not all focused on the studied countries, the results of the case studies as well as the review of existing national studies reveal that these findings hold for the four Nordic countries under study as well. The unusual level of generalisability may be explained by the considerable amount of borrowing and convergence that has taken place in the policy arena over the years. For instance the Italian industrial districts and Silicon Valley are best practice examples with which almost all policymakers in OECD countries are familiar and have attempted to emulate. Likewise, the actual policy mechanisms used for promoting innovation are also converging particularly in European Union countries where the impact of EU programmes is considerable particularly in small countries like Ireland and Denmark. Cooke and Wills (1999) for instance report that SMEs in small countries such as Denmark and Ireland reported unusually high levels of satisfaction with their experiences in EU innovation programmes. Further, Cooke and Wills research also showed that there is a tendency for the same firms to participate in innovation programmes (national or regional). This is particularly interesting from the policy point of view since it implies that it is more likely an orientation to external networking that explains firm participation in such programmes rather than entry costs.

The preferred mechanism for promoting innovation in SMEs is that of developing and maintaining programmes that support network formation between public research providers and SMEs. Much of the research done on assessing and evaluating the success of these mechanisms and programmes shows that

policymakers face considerable difficulties in finding the right policy design, etc. for attracting SMEs (cf. Woolgar and Vaux, 1998; Kaufmann and Tödling, 2002; Prabu, 1999). According to Hoffman, et al. (1998) two of the most important reasons for this are the radical heterogeneity of the SME sector in most countries and the fact that we know very little about the actual conditions under which SMEs do undertake to innovate.

If we take the first mentioned issue, i.e. heterogeneity, one finds that the very tools of classification of SMEs employed by both policymakers and academics alike tend to underreport that heterogeneity rather than make it transparent. A paradigmatic instance is the well established EU classification of SMEs into the sub categories micro enterprises, small enterprises, medium size enterprises, etc. While this is a fairly useful shorthand kind of category particularly for research, it is not particularly efficient for policy purposes since it tells us little about the nature of these firms, their impact on their respective local economies or their potential to innovate. Further several studies show that what distinguishes SMEs from their larger counterparts is not size but ownership structure and efficiency. SMEs are more often owner managed than large companies (Bougrain and Haudeville, 2002) and their share in innovation often exceeds that of their formal investment in R&D (Rothwell and Zegveld, 1982).

Further examination of the policy reports and academic studies of the SME sector reveal that there are at least two crude categories based on the level of technological sophistication which SMEs can be placed and these can be further subdivided into 2 categories each. The first broad category would be new or sophisticated technologies (Caryannis, et al., 1998; Mustar, 1998). This category is further subdivided according to origin of company, i.e. firms that are spin offs (i.e.

originated from universities, public research organisations or larger companies) and firms that are stand-alone entities.

The second category would be firms operating in the traditional sectors (services, manufacturing) or well established technologies. This category may also be further subdivided into two: firms that are strictly speaking part of the traditional sector but have sophisticated R&D needs- some examples would include meat processing, textiles and dairy and those that employ fairly established technologies. This categorisation is rather crude but when complemented with size can serve as a fairly useful way of navigating the SME universe particularly if one's intended destination is some understanding of how and what determines SMEs and PRO collaboration.

Ironically, the problem of ignorance of how SMEs innovate and under what conditions is in part an artefact of the success, which policymakers have had in encouraging academics to do research on the innovative capacity of SMEs. For instance, one of the peculiarities of the SME literature particularly over the last ten years is that the studies cluster around a small number of empirical referents. If one wants to know about SMEs in the biotech sector for instance, there is no shortage of information. As one moves away from biotech, information technology and SMEs in science parks and incubators, the thickness of the information that may be gleaned from the remaining reduces considerably. The reason for this is that policymakers have had an intense interest and pattern of investment in these particular areas. Thus, not only do these sectors attract the most investment but they also attract the most research attention. The problem however is that it is becoming increasingly clear that much of the knowledge developed about these firms and the sectors to which they belong may not be applicable to SMEs in other sectors.

There are however some observations about SMEs and innovation that are applicable generally across all sectors. These findings are summarised in the textbox below.

Box 1.1. List of stable findings on SMEs and knowledge transfer

SMEs in rural areas tend to be more innovative than their urban counterparts although they are less likely to use external sources of knowledge (Keeble and Walker, 1993; Keeble, 1990; Oakey, 1991).

SMEs face serious difficulties in commercializing new products (Pratten, 1991)

The region and immediate local environment is more important to SMEs than to large firms (Asheim, 2002; Tödtling, 2002)

Company expenditure on R&D is not a reliable indicator of innovativeness in SMEs (Rothwell and Zegveld, 1982)

SME perception of the utility and exploitability of a new technology is often dependent on the social distance of the SME from the site of invention (the university) (Woolgar, et al. 1998; ESTA, 1997)

The SME sector is radically heterogeneous and this often leads to contradictory results when comparing the levels of innovativeness between SMEs and large firms, (Kaufmann and Tödtling, 2002; Woolgar, et al. 1998; Acs and Audretsch, 1990; Pavitt, et. al. 1987).

Successful commercialization of academic research depends on the active participation of the researchers who were the original discoverers of the knowledge to be commercialized (Siegel, Waldman and Link, 2003; Zucker et al., 1998; Audretsch and Stephan, 1996)

Commercialization of University Research: State of the Art in four Nordic Countries

Nordic countries in keeping with global trends have been individually developing policy frameworks for supporting the development of their respective national innovation systems. University-industry cooperation and the commercialization of academic research in particular have been assigned a central role in this policy effort.

The results thus far are quite good. According to the European Union's report on key figures for science, technology and innovation for 2000 show that three Nordic countries are above the EU average (3.5%) for individual firm expenditure on innovation, Sweden, Finland and Denmark (EU, 2000). This level of investment is not however matched by a corresponding innovation pay off in these countries. In fact, seen from a global perspective Europe as a whole is not doing well in terms of getting high levels of innovation out of its investment in R&D and many Nordic countries e.g. Swedish policymakers perceive their country to have a particularly acute problem in this respect.

In view of the above, many Nordic countries embarked on intensive programmes aimed at the promotion of the development of new SMEs, the upgrading of the knowledge base and capacity for innovation in existing SMEs and the commercialization of academic research. These three issues may be said to constitute a critical triangle in Nordic innovation systems. In this triangle a number of issues are considered to be hot spots for policy attention. Among these are: the issue of intellectual property rights broadly conceived; linkage institutions and collaborative practices.

The present project has catalogued the efforts over the last decade within Sweden, Denmark, Finland and Norway to pursue these specific policy goals and in this section we shall summarise the main trends in each country as well as analyse in so far as possible how well these approaches have been working. A few general remarks are warranted before going into specifics. Sweden and Finland may be regarded as being the front-runners with respect to innovation policy generally and in particular with respect to policies for the commercialization of academic research and the promotion of new SMEs. Norway and Denmark are somewhat less advanced but

seen from a European perspective, these countries are ranked quite high in terms of innovation performance. The area of innovation policy is one in which Nordic countries have done a considerable amount of benchmarking against each other and against countries outside of the region. Finland for example readily admits that for a considerable amount of time, it copied many of its policies from Sweden, who in turn had copied their policies from the USA. In addition to the efforts by policymakers to keep abreast of developments in neighboring countries, the combined effect of the European Union and the Nordic Ministers' Council (Nordiska ministerrådet) research and policy efforts means that there is a considerable amount of information and opportunity for knowledge exchange.

Since each of the country reports presents a detailed account of the respective countries' initiatives and policies on commercialization, etc. we will focus here on summarizing the vital statistics for the SME sector[1] in each country and highlighting only those approaches which are significant either for the country or for the region. These are promotion of collaborative research using the research council system; reform of intellectual property regimes as they apply to universities; and reform of university structure.

Structure of the SME sector in Denmark, Finland, Norway and Sweden

Denmark: SMEs account for almost 100% of firms (the share of large firms in the total amount only 0.2%), and very small firms (0-9 employees) represent 92% of the total number. SMEs represent 70% of total employment while very small firms generate 30% of the total. Twenty per cent of SMEs were selling online to other companies in 2000 and this share had risen to 27% in 2001.

[1] The data presented on SMEs for each country is taken from OECD 2002, OECD Small and Medium Enterprise Outlook, OECD Paris.

Finland: In 1999, there were 220 000 enterprises in Finland, and SMEs (fewer than 250 employees) represented 98.5% of total firms. Firms with fewer than ten employees account for approximately 90% of the total, while those with more than 500 employees represent approximately 0.1% of the total. Within manufacturing, firms with fewer than ten employees account for approximately 85% of the total, and those with fewer than 50 employees represent 97% of the manufacturing total. Approximately 10% of manufacturing employees are in firms with fewer than ten employees, 24% are in firms with fewer than 50 employees, and 42% work in firms that employ more than 500. The share of manufacturing production by size class was roughly as follows in 1999: 5% of output was generated by firms with fewer than ten employees; 14% was generated by firms with fewer than 50 employees, and about 30% by SMEs; firms employing fewer than 500 generated approximately 45% of manufacturing output. Overall, SMEs are reported to account for 52% of private sector employment, 37% of turnover and 40% of GDP. Sectors where SMEs contribute most to employment are manufacturing, wholesale and retail trade, business and other services, and construction.

Norway: SMEs accounted for 98% of all firms in, and firms employing up to five employees represented approximately 80% of all firms. In construction, real estate, wholesale and retail trade and primary activities, SMEs accounted for over 99% of businesses – slightly more than the share of SMEs in transportation, storage and communications (98%), hotels and restaurants (98%), business activities (96%) and manufacturing (96%). In education and in the oil industry, SMEs accounted for about 89% and 94% of firms, respectively. In terms of employment, SMEs account for 53% of employment. SMEs employ 17% and 36% of workers in the oil industry and in

manufacturing, respectively, and much higher employment shares in some other activities, such as construction (66%), wholesale and retail trade (83%) and hotels and restaurants (71%).

Sweden: More than 99% of all Swedish enterprises are classified as SMEs, i.e. they have fewer than 250 employees. The majority of enterprises (94%) have up to nine employees while about 5% have between ten and 49 employees. Only 0.5% of firms have more than 100 employees and approximately 0.1% have more than 500 employees. Two-thirds of enterprises have no employees at all. In total, three out of five employees in the private sector were employed in SMEs in 2000, and about 35% were employed in firms with more than 500 employees. Approximately 50% of employment was located in firms having fewer than 50 employees. Within manufacturing, approximately 23% of employment was found in firms with fewer than 50 employees while those with fewer than 250 employees accounted for approximately 45% of the total. The importance of the SME sector is also reflected in their contribution to the economy. In terms of turnover, the SME sector accounts for approximately three-fifths of total turnover, while firms with fewer than 50 employees generated over one-third of turnover. SMEs generated approximately 35% of manufacturing output with small firms (fewer than 50 employees) accounting for around 17% of the total. The SME share of the total value added in the Swedish economy is 57%. When it comes to investment, the SME sector accounted for 66% of net investments in 1998. The SME sector in Sweden is therefore of major importance both in terms of employment and economic contribution.

Promotion of collaborative research

With respect to this particular policy measure, Finland and Sweden may be regarded as possessing the most advanced systems and the apparatus found in these countries

in this respect compares well with the state of the art internationally. The system briefly described is based on a policy approach that steers university and public sector research towards more collaboration with industry (both large and small firms) through funding. The main approach utilized in both countries has been to make collaboration a criterion of eligibility for academic proposals seeking funding. The general outlines of the system and its rules are similar in that in both cases collaboration has been made into an obligatory point of passage for receiving research funding. This is achieved through the reservation in both countries of a significant portion of available research funding to collaborative research and in increasing the dependence of public research organizations on competitive research by reducing the size of block grants to such institutions.

While Finland and Sweden have both opted for increasing the dependence of PROs on money obtained through competitive sources, the two systems have some significant differences and these are in part a function of the divergent structures of the public research systems in the two countries mentioned earlier in this document and described in more detail in the respective country reports. These structural differences are also significant explanatory factors in shedding light on the actual performance of the policies in question. It is clear that Finland has been considerably successful in achieving the goals of its collaboration policy while Sweden although relatively successful is still struggling. Swedish policymakers feel in particular that the level of return on investment is lower than that obtained in Finland (VFI, 2002:1). Further it has been argued that the percentage of the budget available to finance public research devoted to problem oriented research is relatively low. The major share of public funding of research goes to universities because the institute sector in Sweden is relatively small in comparison to all other Nordic countries. The position

of the universities as primary knowledge providers has meant that even in a climate of growing dependence on competitive research funding[2], there is no guarantee that research will be skewed to solving those problems that are currently on the agenda of stakeholders. In fact, there is a considerable difference of opinion among many of the actors involved as to whether the proper role of the university is to substitute for the R&D units of private companies. Many of the large firms for instance argue very strongly for a division of labour between corporate and public R&D which leaves the more speculative and future oriented research to publicly funded university projects while company money should be devoted to research with shorter turnaround times. A recent example taken from the Swedish telecom sector is Ericsson's request that government expenditure on telecom research in Sweden ought to increase to 25% of what they estimate to be a reasonable level of R&D investment in the field (Dagens Industri, October 2003)

In Finland, the same set of policy mechanisms have been introduced in a context that is slightly different. Two features present in the Finnish context will be lifted out here to explain and illustrate the differences. The first is that the Finnish public research funding system is strongly centralized even in comparison to the new and more centralized organization of its funding system that Sweden completed in the beginning of 2002. The majority of public money available for funding research in Finland is funneled through Tekes, which provides enormous opportunities for this organization's ability to steer and influence the direction of research. In addition, one of, if not the largest single provider of research in the public system in Finland is

[2] The National Education Agency of Sweden has suggested that no more than 50% of research done at universities should be funded from internal budget allocations (fakultetsanslag). For some universities, e.g. the technical universities the percentage of externally funded research is >60%.

VTT which is a free standing research institute[3]. The fact that one of the largest players on the research scene is a research institute rather than a number of old universities has meant that the Finnish system is potentially more responsive to demands for change. The relative simplicity of the Finnish structure is also assisted by the small size of the innovation system which has hitherto worked as a factor in making the promotion of collaboration easier although not something to be taken for granted (cf. Science and Technology Policy Council, 2003).

Norway and Denmark are comparatively speaking smaller players in the international R&D system. Whereas Sweden and Finland are among the biggest spenders on R&D in the OECD with annual figures for 2002 of 3.8% and 4.4% of GDP respectively, Denmark and Norway spent about 2.09% and 1,7% [4]of GDP respectively which puts them lowest in the Nordic region. The low level of their national expenditure on R&D is about the only thing that these two countries have in common. Unlike Sweden and Finland where there is considerable similarity in innovation policy as well as relatively early disposition towards innovation policy reform, detailed attention to innovation policy generally and to the role of universities and the commercialization of knowledge in such policy is a recent phenomenon in both Norway and Denmark. In the Danish case, the spring of 2003 will see the announcement of a number of reforms in the area of interest to this report. This includes university reform and policies for university-industry cooperation. While it is remains unclear what the details of Denmark's proposal on the commercialization of academic knowledge will be a number of features are already apparent. These include simplifying the structure of the research advisory system and improving the transparency of the public research system. More specifically, Denmark will

[3] VTT is a 3000 employee organisation devoted to technical research and has an annual budget of 200 million euros.
[4] Figures taken from OECD 2002, Science, Technology and Industry Outlook, OECD Paris

introduce a number of new initiatives for regional development called regional growth environments. These will be founded on collaboration between industry, research and educational institutions, technological service providers (i.e. GTS) and other relevant actors and takes its point of departure in homogeneous industrial competences in a geographical area.

Norway has just introduced its reform in this area (January 1, 2003), one of the key aspects is the removal of the 'professor's privilege/teacher exception clause' (see chapter 2 below for more detailed information on this issue). This is being buttressed, for example, by the further development of special funding arrangements for commercialisation. This reform puts a new light on the mainstays of university-SME relationships in Norway such as the central "Research-Based Innovation and Start-ups" (FORNY) program for commercialization of research, the SME-oriented "Mobilizing R&D-'Related Innovation" (MOBI) program, and the role of the regional network of research parks and incubators (SIVA). It remains to be seen how these different pieces of the puzzle will come together in the light of the new legislation.

Reform of the intellectual property regime with respect to universities

Academic staff at universities in Nordic countries is subject to a convention known as the 'professor/teacher exception clause' which entitles them to ownership of any property rights that accrue from their research. The increased interest on the part of Nordic governments in promoting the commercialisation of research produced in public research organisations has led to intense debates in the respective countries about the role of the teacher exception clause. Although there are important differences of opinion between academics and policymakers on this issue, it would not be unfair to say that the policy position may be characterised as one which is

favourable to removing the convention and placing ownership with universities or the employing organisation. Each of the individual countries has in keeping with this, commissioned its own studies of the issue and this has resulted in a number of proposals for changing the ruling. The state of the art is different in each country and even in the cases where the ruling has been changed; it is still so recent that it is not possible to evaluate its impact. We will however summarise the situation as briefly as possible. Denmark was the first country to legislate a change in the teacher exception clause and grant rights to employing institutions. This legislation was introduced in 1999. The absence of any other supporting mechanisms for commercialisation such as patent offices, changes in the competitive research system, university reform, etc. has meant that the change in ruling has had little chance of making any impact on the system. Anecdotal accounts about increased numbers of patent applications since the legislation often cite rather modest numbers but a more systematic investigation of the state of the art since the changed legislation is clearly needed.

A report from a round table of Danish researchers held in December, 2001 concurs with the estimation that there was little impact of the changed ruling but did report that there has been some reduction of the outflow of ideas from the university but there was an impression that this may be a short lived outcome (IVA, 2002). What the Danish experience tells us so far is that removing the teacher exception clause is a necessary but not a sufficient incentive to commercialisation. In Norway, a new law removing the teacher exception was introduced in January 2003. This new ruling was announced together with a number of other measures such as funding for commercialisation and support structures such as research parks, incubators, etc. It will be interesting to monitor the outcome of the Norwegian approach since it is the

only Nordic country that has attempted to introduce the mechanisms for reform of the system more or less simultaneously.

Sweden and Finland are both behind with respect to introducing legislation changing the teacher exception clause. The issue has been under study in both countries for some time and the fact that in both instances, there is a whole infrastructure for commercialisation present implies that it should be easier to reap any potential benefits to be derived from a change in legislation. In May 2002, a new Act was introduced in Finland which proposed among other things changing the status quo with regard to the protection of intellectual property rights in universities. The intention is to grant employers the rights to intellectual property developed by researchers. This also implies that universities would also have the rights to intellectual property developed in collaboration with third parties. The new Act would not cover the intellectual property rights in free academic research, where the inventor has the right to decide the primacy of publishing and utilisation of his/her invention. However, the Act would be contractual: the regulations would be applied if not contracted otherwise by the parties involved. The amendment would also bring the IPR practice in Finland closer to the prevailing practice in other member states of the European Union, the US and Japan.

Sweden has not yet introduced any changes in the teacher exemption clause although there have been attempts to raise the question and studies proposed and performed (cf. Henrekson, M. 2002; Vinnova) . Swedish universities and academics are divided on the issue while policymakers are more or less convinced that teacher exemption is an obstacle to commercialisation. In the limited number of case studies done for the Swedish country study, entrepreneurs highlighted the teacher exemption clause as a factor in promoting their interest in starting a company. This particular

finding is not regarded as important however since policymakers usually point to the other experiences (most particularly the American experience) as evidence that researcher entrepreneurs have always resisted initial attempts to give universities the right to intellectual property. The latest development is that Vinnova has recently proposed in a letter to the government advising on the issue that the professor exception clause be maintained (see Swedish country study and www.vinnova.se for further details.

On the part of the universities, it would not be unfair to say that with the possible exception of institutions such as Chalmers and Karolinska, most Swedish universities are wary of the IPR issue. The major reason for this caution is the perception that owning and developing IP is costly both in terms of financial capital and expertise. Most Swedish universities are quite cash strapped as it is and their existing organisational structures are not even developed enough to deal with the growing demands from contract research, let alone dealing with IP issues. Chalmers is one of the more advanced universities in this respect, in that apart from its own patent and venture capital companies, it has a centre for research on the issue of intellectual capital (CIP) and is working actively to build a consensus among its researchers to accept turning over IP to the university.

It should also be noted that in principle, the State does not have to legislate on the issue of the teacher exemption clause, individual universities could in negotiation with their employees institute local rules if they choose. There are also a number of existing cases where such local initiatives have been taken by individual academics. The preferred approach in these cases is also consistent with international practice in that it usually involves a three way split between the researcher, the university and the department.

University reform

All countries have identified university reform as an important feature if attempts to integrate universities and PROs in the respective national innovation systems are to be successful. As with the other issues, there are considerable differences with respect to progress on the issue cross nationally. It is important to bear in mind however that the importance of the universities to innovation policy differs radically in the different countries. In fact, one may argue that given the extensive breadth of the institute sector in most countries, it is only Sweden for which university reform may be said to be an imperative for the success of innovation policy. That being said, it is also necessary to recognise that in all countries some reform of the public research sector is mandatory if the twin goals of collaboration and commercialisation are to be realised successfully. In the immediately following paragraphs we will elaborate on the state of the art with respect to university reform in two Nordic countries as examples. Sweden will be used because of the dual reasons of the importance of the university in that country's public R&D and because it has been gradually reforming its universities over a decade now. Denmark is the other example because it is a latecomer in this respect in regional terms.

In Denmark, university reform is now being introduced and will focus in the first instance on reform of the governance structure of universities to allow for more influence from stakeholders from the wider society. While there has been intense debate and some skepticism from the research community on several of the points proposed in the Bill, it appears that the Bill will be enacted. The nature of the specific reforms that will be introduced with respect to details such as commercialization of academic knowledge, competitive to fixed funding for research ratios, etc. is still unclear. All of these issues are under review however and it is expected that an

OECD mission will visit Denmark later this year to discuss issues associated with higher education, etc.

In Sweden, the process of university reform has been an incremental one that has been taking place more than a decade now. Some of the main highlights of this reform process are:

- Reform of doctoral education, introduction of graduate research schools
- Professors' reform
- Representation of external stakeholders on university boards
- Limited experimentation with diversity of ownership of universities (2 new foundation universities)
- Introduction of university holding companies to overcome barrier to ownership in the existing legal structure of most universities
- Legislation of the Third Mission making universities legally responsible for disseminating research results produced within their organizations
- Regional university colleges integrated into the strategy for development in the regions

Despite the impressive list of reform above, there are a number of outstanding issues that require attention if Swedish universities are to be able to cope with the increasing demands placed on them by commercialisation and collaboration efforts. This is particularly so since in Sweden unlike other Nordic countries, it is the universities that form the front line in the public research effort. These issues will be summarised here briefly in list form:

- Reorganisation of the administration to make room for proactive administrative structures that are based on a support ideology rather than the current caretaker mentality that prevails;

- More flexible recruitment structures to allow universities to hire staff in relation to present and anticipated demand;
- Financial and policy support for organisational change within universities
- Reform of the incentive structure to allow commercialisation to be integrated into the academic merit system; and
- Universities need resources and encouragement to plan personnel recruitment in a strategic fashion in the light of the impending demographic shift.

Policies for promotion of SMEs

One issue has cropped up in all of the different country reports and this is that all countries have very high levels of policy interest in the promotion of SMEs generally and new SMEs in high or new technology areas in particular. As mentioned earlier, there is considerable cross national convergence of policy in this area because of the European Union programmes, the visibility of best practice cases particularly from the US and Italy and finally the impact of academic input of cross national comparative studies, etc. Generally, the focus of policy in the Nordic countries has had one major noteworthy shift in the last ten years and this is towards promoting entrepreneurship rather than support to SMEs. This is not to say that programmes to support SMEs are receiving lower priority or that this focus is found with the same intensity in all countries. However, the onset of interest in entrepreneurship has meant that policies for promoting SMEs have become more diverse and wide ranging. This expansion of range and breadth has meant that in many instances, it is difficult to discern any coherent direction apart from a general desire to promote SMEs. The most powerful trend that can be discerned is a shift from directed support programmes to those which focus on framework conditions. This is connected not

only to the interest in entrepreneurship but also in the recent move towards providing incentives for the development of clusters or innovation environments. Such clusters include regional development schemes and so allow policymakers to more efficiently use resources to promote the development of critical mass.

The individual country reports provide considerable amount of information on specific country initiatives so the input here will be of a summary and analytical nature. Box 1.2 provides a bulleted overview of the main trends and this is supplemented with some detail on each point in the immediately following paragraphs.

Box 1.2 Overview of the main trends of SME support in Denmark, Norway, Finland and Sweden

- The overarching trend is towards a focus on nurturing entrepreneurship in general rather than supporting SMEs per se
- The dominant approach to SME support is one of resource deficit with emphasis on finance and knowledge as the resources most needed
- There has been a significant diversification of the financial mechanisms available to SMEs
- New financial support mechanisms include public and venture capital as well as the soft loans that characterised the last generation of SME support programmes
- Growth of a fledgling private venture capital market

Generally, national policies for promoting SMEs take a resource deficit approach (i.e. they try to identify resource needs and fill the gaps wherever possible) and focus on two pillars: finance, and knowledge. The financial area is probably the one that has

diversified the most since the traditional SME promotion programmes of the last decade have been revitalised. The new financial support mechanisms include public and venture capital as well as the soft loans that characterised the last generation of SME support programmes. The private venture capital market is a new phenomenon in all the Nordic countries and there is a general consensus of opinion that the current generation of venture capitalists is neither competent nor risk prone enough to meet the demands in the market. This implies that public venture capital will continue to play a significant role in the near future. The recent downturn in the fledgling venture capital markets in Sweden and Denmark are seen as confirmation of the immaturity of the market as a whole.

Although venture capital remains a problem, the issue of connecting up SMEs to knowledge providers is seen as equally acute if not more so from the policy side. There is one case that uses the venture capital model to provide an interesting solution to the problems of competence as well as access to university knowledge. This is a university spin off company that provides competence to small start-ups in need of knowledge and business advice in exchange for equity.

The results from our case studies conducted in the different countries confirm that access to knowledge is a thorny problem particularly with respect to SMEs in the traditional sectors. The main obstacle from the point of view of traditional SMEs relations with universities continues to be that SMEs do not see universities as potential sources of knowledge. A shortcoming of many of the programmes that aim to support SMEs and provide access to new knowledge is that they often overlook the fact that SMEs often value sources of knowledge such as other firms, suppliers, trade fairs and exhibitions more than contacts with research providers of different types.

While these sources may have obtained their knowledge from universities, there is no way that they can be traced directly to universities.

The SMEs that do report high degree of contacts with universities are unsurprisingly predominantly those whose business areas are located within the new or high technology areas. Apart from the technology pull factor that seems to drive networking with academics in this sense, the entry and maintenance costs for engaging in these networks are significantly reduced for these SMEs because of social proximity. This social proximity is based on the fact that the employees and/or founders of such companies have themselves been university graduates and it is their personal networks that are the initiating links in the networks that the companies later develop. Many of the SMEs in the new and high technology sectors are based on university knowledge and these companies naturally are wary of policies that encourage universities to commercialise knowledge themselves. Thus far, even in cases where universities have the right to commercialise their knowledge, it has not led to much direct impact on network relations with SMEs. The reason for this is that universities do not at present possess the resources to commercialise all of the knowledge in their possession.

A second and related reason is that many of these networks are highly idiosyncratic and individual and universities as a rule do not collect systematic knowledge about employee networks. The reason for this is that if they were to attempt to, it would be a large undertaking the costs of which would outweigh the benefits since every faculty member and doctoral student is a potential network node. There is one potential benefit to the absence of systematic record keeping on networks at the level of the university. One is that it will be a corrective balance to

any eventual restriction in the outflow of ideas from universities as they become more interested in commercialising knowledge themselves.

Policy conclusions

Create incentives for individual academics to commercialise their knowledge

All countries have a significant gap in their policies with respect to incentives for promoting commercialisation of university knowledge. Although mechanisms for assisting such collaboration have been put in place in most countries and are being put into place in others, commercialisation activities are still not part of the academic merit system. This implies that there is little incentive for individual academics to engage in such activities.

Increase mobility of human capital between the university and business sectors

Restricted mobility of human capital is still a significant obstacle to knowledge transfer between universities and industry in the Nordic countries. Apart from the differential rates of remuneration in the two sectors, other significant contributing factors include cultural differences and the structure of the pension systems.

Remove legislative barriers to the commercialisation of knowledge

Although much emphasis is placed on the IP issue when discussing the commercialisation of academic results, there are a host of less visible legislative barriers to commercialisation in the different Nordic countries ranging from rules prohibiting investment by research organisations in private firms to restrictions on public servants engaging in competing economic activities. These will have to be reviewed and revised in the light of new policy interests.

More coherence in SME support programmes

Many governments have tried their best to create one-stop facilities for SMEs however there is still a need for coordination and dissemination of information to decrease the search costs to SMEs seeking information. The Danish approach of coordinating national and EU support programmes for SMEs is one potential route to setting up one stop facilities.

Support and supplement the development of competent venture capital

Most countries report that the private venture capital market is too immature and risk averse to be helpful to young companies. There is therefore a strong need in the Nordic setting for public intervention in the capital market.

Promote enterprise culture

Nordic countries have on average a low innovation outcome in relation to level of investment in R&D. In the two largest R&D spenders, Finland and Sweden this is particularly acute. This implies that the promotion of enterprise culture is a regional problem that needs to be addressed not only with respect to universities but also on a societal level. This could be achieved through more widespread use of entrepreneurship modules in education not only at university but also at high school level. Further, attention needs to be given to making it transparent to all citizens how one moves from idea to company through the provision of public information about the different programmes, institutional supports, etc. that are available.

Diversify the sources of knowledge on offer to SMEs

PROs are often not the preferred source of knowledge for the average SME. It may therefore be equally important to integrate other knowledge providers in technology transfer programmes on offer to SMEs. Some countries already have programmes that encourage network formation between large and small companies. This can be further developed to include support for trade fairs and exhibitions. PROs can also be encouraged to participate in such events as far as it is possible.

Provide support to organisation development at universities and other PROs

Many universities and PROs in the countries studied simply lack the resources and organisational structures needed to support the new mission that is now their responsibility. More attention needs to be given to how support and resources can be channelled to these institutions to assist them to develop the necessary infrastructure. Existing programmes of this kind are overly focused on financing the building of structures like technology transfer and patent support offices. Less attention is given to the more important issue of providing competent management support to bridge the gap between the current administrative ideology that prevails in PROs particularly universities and the ideology that dominates in the new infrastructure of patent offices, etc.

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Chapter 2: Country Report, Norway

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Introduction

In the 1980s, efforts to improve the climate for commercializing university research explicitly recognized the importance of the link with small and middle-sized enterprises (SMEs). At that time, a major premise for policy was in fact that, "universities could contribute to the revitalization of national economies by assisting small and medium enterprises as well as by generating entirely new high-technology businesses." (Stankiewicz, 1986: 3) Today, this focus on the university-SME (the U-SME) link has re-emerged amidst a new phase of policy activity designed to improve the basis for turning "science into business". [5] Norway, like many other OECD countries, is currently trying to define the new role of academic research. The question that has yet to be asked is how these efforts will effect the interaction between the country's few large universities and its many SMEs.

This report explores the changing relationship between academic research and SMEs as it is taking shape in Norway. It is designed to promote cross-country comparisons with Nordic neighbours in order to improve our understanding of the basis for policy initiatives, their substantial context, and their (potential) effect. This national report systematizes knowledge about commercialization of academic research and reviews existing formal and informal mechanisms for knowledge exchange between SMEs and universities. Particularly, it provides an overview of the current interaction between the university sector and the large population of Norwegian SMEs (the 'U-SME relationship'), it describes the instrumental regulatory and institutional

[5] In Benchmarking of Science-Industry links, the OECD listed "Promoting the participation of smaller firms" as one of six important policy concerns. (OECD, 2002: 10)

factors that shape the U-SME relationship in Norway, and it discusses relevant policy-challenges with an eye to further improving the relationship.

This report is divided in five main sections, including the current introductory section. Section 2 presents baseline information about the industrial structure and innovation activities in Norway as they involve the university sector and the SME sector. This presentation provides comparable information about factors that condition the current state of U-SME relationship in Norway. The third section goes on to provide a digest of the changing policy-framework and institutional support structures in Norway that have particular relevance to the U-SME relationship. This public R&D section surveys the major instrumental regulatory and institutional factors that shape the U-SME relationship, and reviews an array of relevant policy-initiatives in terms of their place in the wider innovation system. Section four then takes stock of the current degree and extent of the relationship between academic research and small and middle-sized enterprises in the country. We collect existing empirical evdidence about academy-industry links before presenting four case-studies in order to identify current concerns and problems in the U-SME relationship. On the basis of current state of academy-industry interaction, the final section concludes by reviewing policy initiatives and discussing inititatives which might improve the interaction between university sector and SMEs.

Industry Structure and Innovation Activities in Norway

A defining characteristic of the Norwegian research environment is that, in international terms, a disproportionate proportion of research is publicly financed. The Norwegian university sector, which consists of a few large institutions, is responsible for more research than the international average. The situation of the Norwegian private sector is diametrically opposed. The private sector is characterized by a large

proportion of very small firms who, on average, report innovation activities considerably below the Nordic average. Several of the salient features of formal R&D activities in the Norwegian case are listed in Box 2.1.

Box 2.1. Formal R&D in Norway: Expenditure and Employment

- The absolute level of R&D expenditure is modest in Norway: 1.7% of GDP or a NOK 4,554 per capita. This is below the OECD average, and the lowest in the Nordic area
- The proportion of publicly-funded R&D is the highest in the Nordic area, at 43% of total R&D expenditures. By implication, the private-sector R&D is the lowest at 47% (1999) which is similar to the Netherlands and Great Britain.
- The academic sector[6] accounts for 29% of total R&D expenditure, with the four universities alone accounting for 23% (1999) and 23% of total R&D employment. (1999) This places Norway among the top OECD countries;
- In this perspective, the R&D activity of industry and mining is roughly equivalent to that of the four universities.
- The Publicly sponsored research (universities, colleges, research institutes) accounted for only a fifth of R&D services bought (4,4 BNOK)
- The Norwegian industrial sector is characterized by low and relatively stagnate levels of R&D expenditure per capita. (NOK 2,000 (1990 kroner) in 1999)
- R&D expenditure is relatively evenly spread in Norway across R&D intensive sectors. The absence of R&D intensive world leaders in Norway (areas such as cars, aeronautics, communications) affects the R&D bottom line. (ANBERD 2000)

An important dimension to highlight in our context is that most Norwegian companies have relatively small R&D budgets, while the few universities have large ones. The institute sector, which is large in Norway, is in between. Table 2.1 illustrates how annual R&D expenditure breaks down between the private, the institute, and the academic sectors.

Table 2.1: Number of entities conducting R&D in Norway by how much they spent on R&D in 1999: private, institute, and academic sector.

	Industrial sector[7]	Institute sector	University Sector		
R&D expenditure: MNOK		Reseach institutes[8]	Universities	Schools of higher learning etc	PublicUniversity colleges
< 10	1 261	42	-	5	6
10-49	161	49	-	5	17
50-99	28	13	-	2	3
100-499	21	9	1	2	-
500-999	3	1	1	-	-
> 1 000	-	-	2	-	-
Total	1 474	114	4	14	26

Source: NIFU, Statistics Norway

[6] This role and the level of R&D is monitored by the UoH survey and institute surveys. (NIFU)
[7] Estimated number of entities (scaled sample for smallest size-classes)
[8] Excluding museums and hospitals.

General policy environment

The combined fact of high levels of publicly funded research to a small number of large public institutions and low-levels of formal R&D among a large number of small firms, has presented the Norwegian policymaker with something of a quandary. In sum, this situation has left him (and her) faced with a headline level of R&D which, at 1.7% of GDP (1999), is by an uncomfortable margin the lowest in the Nordic area. Indeed, the level of formal R&D is below the OECD average: getting it above that level has (again) become the holy-grail of the country's formative innovation policy.

In our context, this has led two policy questions to be (re)asked in Norway. The first is how to promote greater returns from public investments in academic research, while not undermining the traditional values and role of academia. This relates to the policy objective, which is very current in Norway, of promoting greater commercialization of academic research. This objective has now been linked to efforts (new and old) to promote the diffusion of academic research through commercial channels. This is currently evolving as a multi-level effort to improve the conditions for the *commercialization of academic research* in Norway. The general objective is to increase the rate and degree of exploitation of the science base, thus improving the basis for economic growth. This particular policy area is not new in Norway. However, it has entered a defining stage of development. One element (Proposition 40) is a set of changes that effectively expands the societal responsibilities of universities and colleges to include promoting the practical application of research methods and results, not least in industry.[9] This change is

[9] Proposition 40 to the Odelsting: Ot prp. Nr 40 (2001-2002): § 2 nr. 4. <<Institusjonene har ansvar for å formidle kunnskap om virksomheten og for å utbre forståelse for og anvendelse av vitenskapens metoder og resultater, både i offentlig forvaltning, kulturliv og næringsliv>>

complemented by more instrumental legislation[10] which recently went into effect. The implementation of Proposition no. 67 substantially changes the basis for commercializing academic research in Norway. The measure effectively removes the 'professor's privilege' from the legal corpus, thus placing responsibility for commercialization of academic research on the universities. It explicitly follows developments in other countries (e.g. Denmark, Germany). The combined change in regulatory framework has served to bring Norway to a critical stage in its policy re-evaluation of the commercialization of academic research.

The second basic policy question is related. It asks how to promote innovation-activity in the country's large population of small firms. This complicated question is linked to a more general and long-standing concern about industrial renewal in Norway, which is associated with recurrent concern about the post-oil economy. This is also a policy-area that has a relatively established tradition in Norway (and elsewhere), going back to the 1980s. It works from the premise that the Norwegian private sector is dominated by firms that are, taken as a whole, smaller, more traditional, and less innovative than competing firm-populations. As with the policy area dealing with the commercialization of academic research, the focus on SMEs has recently become a policy priority in Norway. This prioritization has readdressed many of the policy instruments that in effect bring SMEs and university research together in Norway. The current process to consolidate the support structure for innovation[11] addresses some of these. The overview above indicates that, whereas public investment in university sector research is high, the level of innovative activity in Norwegian industry is moderate. Based on this characterization, policy instruments

[10] Proposition No. 67 to the Odelsting (2001–2002). Amendment to increase the commercial exploitation of inventions. This amendment changes the 'professor's privilege' (lærerunntaket) of Act No. 21 of 17 April 1970 relating to the right to inventions made by employees.
[11] See the recent White Paper: St.prp nr 51 (2002-2003) Virkemidler for et innovativt og nyskapende næringsliv. (28.03.03)

have tended to focus for example on 'growth sectors', but also on improving the circumstances of small companies more generally by encouraging links with academic research.[12]

Thus, interaction between the university sector and the SME-sector increasingly takes place at the intersection of central and highly active policy-areas in Norway. This is occuring just as the country is currently framing an 'integrated innovation policy',[13] entailing a consolidation of diverse policy measures and instruments across ministries. This process impacts and substantially involves these two threads of policy. The changing policy environment in Norway highlights the importance of the new role of academic research in Norway and its implication for SMEs. A primary observation is therefore that the relationship between academic research and SMEs combines two important, but not entirely integrated focus areas of Norway's formative innovation policy.

Norwegian SMEs and the economy

The level of innovative activity in Norwegian industry is thus moderate. The intensity of innovative activity in general—and formal R&D activity in particular— is influenced by basic features of Norway's industrial demography. These include Norway's large proportion of small firms and the dominance of services and traditional sectors.

Box 2.2. Industrial demographics: how many SMEs

Firm-Size: The private sector (130,000 active enterprises) is dominated by small and middle-sized enterprises (96% of the population) with a high proportion of very small firms;
Industrial-distribution: A large majority of Norwegian enterprises operate in the Services sector (including Wholesale and Retail), while less than 10% are found in Manufacturing. Public administration, defence, and other services such as health and education (but not R&D services) account for a further 10% of Norwegian enterprises.

[12] Note that the competitiveness of SMEs is the subject of a recent ministerial Action Plan for SMEs. It is furthermore the focus of the MOBI program (and its antecedents).
[13] The so-called "helhetlig innovasjonspolitikk". This work is scheduled to result in a Parliamentary White Paper (Stortingsmelding) in Autumn 2003.

SMEs dominate the Norwegian onshore economy in number. Nearly 90% of Norwegian firms have less than 50 employees. The abundance of very small firms is peculiar and can be linked to the size of the domestic market as well as the orientation of industrial activity in the country. The firm's ability to innovate by itself may be constrained by size. This suggests a latent potential among innovative or potentially innovative Norwegian firms to contract or partner with academic research.

Table 2.2 provides a breakdown of Norwegian enterprises that reported active employment (in 1998). This register-data indicates that SMEs (based on a definition[14] of enterprises with less than 100 employees) make up 96% of the approximately 130,000 Norwegian. The bulk is to be found in the smallest size-classes, where over 60% are micro (1-4 employees) while 90% are small in the Norwegian classification.[15]

Table 2.2. Norwegian enterprises with salaried employees (1998) [16]

	# enterprises	% total
MICRO (1-4)	81461	63,2
SMALL (5-49)	33959	26,3
MEDIUM (50-99)	8464	6,5
LARGE (100+)	3718	2,9
UNKNOWN	1290	1
TOTAL	128892	100

Source: Iversen (2001)

So, although there are four universities in Norway, there are over 120,000 SMEs in the country. It is obviously impossible to guess how many existing SMEs are potential partners for academic research in Norway. However, it is reasonable to suppose that (i.) the scope for improving the SME-Academic relationship is high but

[14] Our definition means that an extra 1000 enterprises are considered large compared to if we had used the 100 employee cut-off.
[15] A sizable, additional population (over 30% according to Spilling) register no employees and are not included here.
[16] One percent could not be associated with size-classes. The definition is based on enterprises (foretak) with 100 employees or more. In addition, smaller enterprises are considered large if they have 99 M NOK in annual turnover (an average of 1 million/employee, include 15 establishments, and area registered holding companies (NACE 74150) with at least 30 employees.

that (ii.) the majority of existing SMEs in Norway are not currently receptive to collaboration with universities. In these cases, the scope for increased partnerships with academic research or research institutes is limited or at best latent.

There are several aspects about individual small and middle-sized enterprises that help shape their potential to link with academic research. The industrial activity in which the SME is engaged in, its life-phase, its propensity to innovate, and, more obliquely, its propensity to patent are all indicative of the potential scope for increased partnerships with academic research. These aspects are briefly considered here.

A breakdown of the Norwegian enterprises according to general industrial activity[17] indicates that a large majority of Norwegian enterprises operate in the service sector (including wholesale and retail). Most of these are small firms. Less than 10% of all Norwegian enterprise is found in manufacturing, where larger firms are more predominant. Public administration, defence, and other services such as health and education (but not R&D services) account for a further 10% of Norwegian enterprises.

Box 2.3. Innovation activity in industry

- Under 50% of Norwegian firms report innovative activity (the lowest reported in the Nordic area)
- Expenditures reported for broader 'innovative activity' (CIS2) are also relatively low in a Nordic and a European perspective. Norwegian expenditures totalled 2.7% of industrial turnover
- Expenditures are highly industry dependent: with Cellulose, business-services, and chemicals all over 5% of turnover (1997)[18]
- Expenditures are highly-size dependent: SMEs estimated at 1.5% of turnover, the largest enterprises (over 500 employees) reporting over 3.5%.

The industrial sector is characterized by low (in Nordic terms) and (as of 1999) relatively stagnate levels of R&D expenditure per capita. This fact is partly accounted for by the industrial structure in Norway. R&D expenditure is relatively evenly spread across R&D intensive sectors. It should also be appreciated that the absence of R&D

[17] The enterprise's principal product or service is used to assign an industrial activity. By NACE. Source: AA database. Iversen, 2001.
[18] Cf Braadland et al. Step-report R-01: 2001.

intensive world leaders in Norway (i.e. very large multinationals in areas such as cars, aeronautics, communications) affects the R&D bottom line.

A follow up question is where new industries will come from. In Norway, it has long been the expressed hope that this renewal will come from academic research that is spun out into the economy in the form of start-ups. Another indicator of academic partnering is therefore the turnover or renewal rate in Norwegian industrial sector. In Norway the turnover rate is relatively high. The registration of companies with tax authorities suggests that as many as 1 out 10 Norwegian companies (with employment) die every year, while a slightly larger number of companies are established. This large turnover indicates a renewal process where there is potential to improve the role of academic research.

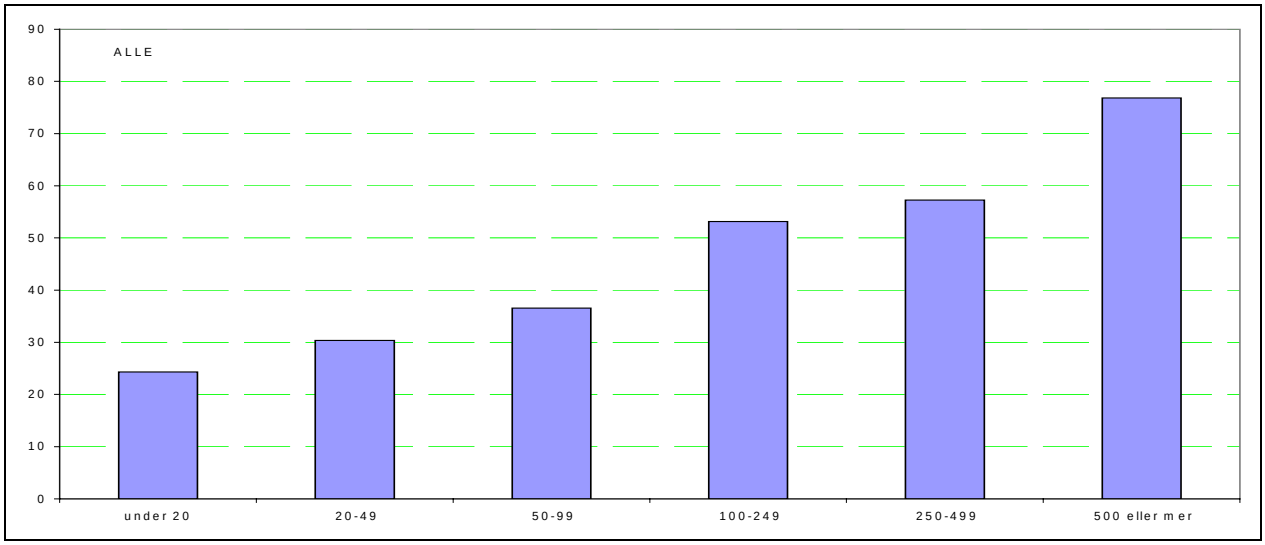
SMEs and R&D Activity

The question of how enterprises innovate is central to their current and potential scope for links with academic research. The results from the pan-European Community Innovation Survey (CIS) demonstrate differences in "innovativeness" among Norwegian firms based on size and industry. The survey suggests some peculiarities about Norwegian enterprises as a population. It also confirms the expectation that the largest firms display a markedly higher propensity to innovate than the smaller.

On average, roughly 80% of the large manufacturing firms in the European Economic Area report that they introduced innovations during the period. Figure 1 indicates that the Norwegian average is slightly below this: 75% of large Norwegian firms registered new or improved products in the period. This is similar to Sweden and Finland for example, and many other European countries. (Eurostat: 24) Another general tendency which Norway follows is that the propensity to innovate falls by

size-class. According to the stratified sample of the smallest size-classes (from 9-20 employees), less than one in three SMEs are innovative.

Figure 2.1: Proportion of Norwegian enterprises reporting innovation activity by size, 1997: Percent.



Source: Braadland et al, 2001.

This impression is consistent with other observations. Based on an earlier Community Innovation Survey (1992), Isaksen & Smith (1997) found that, "the proportion of innovating firms in a size class rises with firm size. Among the firms with less than 10 employees, only 16% engaged in innovation activity, as opposed to 72% for firms with more than 100 employees. This suggests that the scope for increasing activity in SMEs may be large." (Isaksen & Smith, 1997)

SMEs and patenting

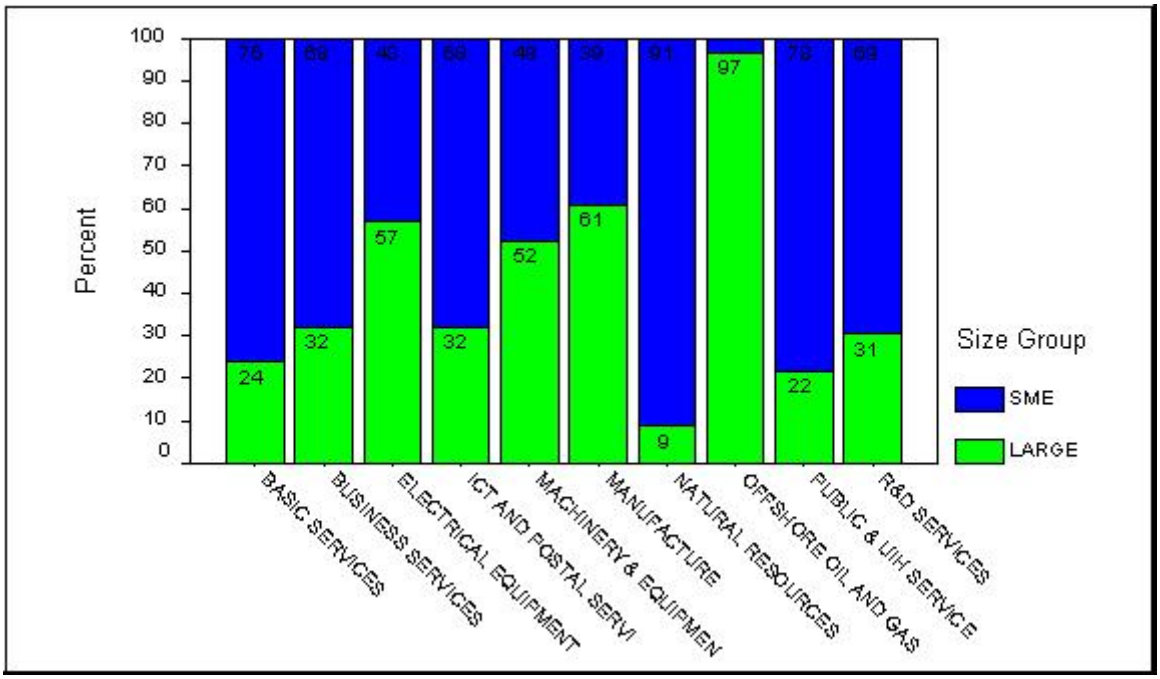
Domestic patent data provides further information about the formal R&D activities of Norwegian firms in general and SMEs in particular. In general, "innovative" Norwegian firms apply for patents less often than those in any other European country, save Portugal (CIS2). Although this indication is crude (it does not take into

consideration industry-effects, etc for the individual countries), it is broadly consistent with anecdotal evidence.

Recent analysis supports the impression that SMEs are considerably less involved in patenting than are larger firms. In relative terms, large Norwegian enterprises apply on average for domestic patents 40 times more often than micro enterprises; 20 times more often than small; and eight times as often as medium-sized enterprises. (Iversen, 2001) In absolute terms, however, roughly the same number of patents is applied for by domestic SMEs (2,571 during the 1990s) as by large domestic companies (2,681).

Figure 2.2 shows how the product area affects the relative tendency to patent among SMEs. It indicates that SMEs in fields such as basic services and natural resources accounted for disproportionately more applications than larger companies.

Figure 2.2 Applications by applicant's industry and size-group (n=4,312)



Source: Iversen (2001)

Note that small entities were also active in R&D services and the university sector, especially through research institutes.

In general, it should also be noted that domestic patenting has risen strongly during the 1990s (VT, 2001). The strongest growth (unadjusted) has in fact been in SME-applications. Encouraging the rise of propensity to utilize the patent system among SMEs is a policy goal. At the end of the decade, policy measures were introduced to reduce the cost of applications especially for small and medium-sized companies.

Basic Dimensions of academic research

In this context public research organizations play a dominant and changing role in the Norwegian innovation system. There are two peculiarities about this role in terms of how it factors in to university-industry relations in Norway. The first concerns the large sector of specialized research institutes (114) that forms a middle-ground between the public and the private sectors. This sector of diversified research institutes has during the past 50 years or so played important roles in partnerships with SMEs (often facilitated by other policy initiatives). They now constitute an important intermediate space for the commercialization of academic research. However, the institute sector does not form a formal fixture of the academic sector[19], with the consequence that research institutes can adopt their own rules concerning the ownership of research results.

Box 2.4. The public research sector

- Academic research is strongly public, with only isolated examples of relevant privately funded activity (for ex. BI)
- The university sector is concentrated around four public universities
- The population of college consist of a further 6 university-colleges and 26 regional colleges

[19] Cf. Law of 12 May, 1995, number 22 concerning Universities and colleges.

- In 1999, 9,000 permanent researchers were registered in the Norwegian university sector,[20] 24% of which are professors. (NIFU, 2002)
- The institute sector makes an important element of the Norwegian research environment. The sector is large and relatively decentralized in Norway, with 128 institutes of different descriptions receiving public support and 114 reporting R&D.

The second observation concerns the university sector. The academic sector falls into four general categories: universities (4), public university colleges (26), schools of higher learning (6) and private university colleges (21).[21] The four (current) universities[22] form the centerpiece of the academic system, both in terms of research and teaching.[23] The university sector is peculiar in that it concentrates large R&D expenditure among a small set of large institutions. The combined R&D expenditure and employment of the four state universities alone account for 23% of the country's total, which is roughly equal to industry and mining together.

The university sector is also overwhelmingly public. In fact the public universities and colleges have a common-organ, the Norwegian council for higher education (Universitets- og høgskolerådet). Again, the majority of research activity today is concentrated into a small minority of the 57 institutions, with only a few current exceptions among private colleges.

However, the university sector continues to experience a period of reshuffling and consolidation, a tendency also found in the institute sector. During the mid-1990s, over 90 regional colleges were consolidated into the current 26 state 'høgskoler'. Whereas the state universities are all, to different degrees, research-performing public institutions, this is not the case for the colleges. Many are principally teaching centers and currently perform little research. According to the R&D survey (NIFU/SSB) six

[20] Vitenskapelige og faglige personalet. Note that these include salaried PhD students.
[21] Translation from the Norwegian Social Science Data Service (NSD)
[22] These universities are the Norwegian University of Science and Technology (Trondheim), the University of Bergen, University of Oslo, and the University of Tromsø.
[23] The University of Oslo is the largest, and its growth is indicative of the changing university sector. It has 32,000 students and 4,500 employees spread in eight divisions(2000). The volume of PhD students has more than quintupled since 1990, to over 1500. The number of fellowships has tripled.

of these perform less than 10 million NOK of 'research', while only three report R&D expenditures in excess of 50 million NOK. There is a further set of six schools of higher learning.[24] At least two of these actively collaborate with the private sector on R&D projects: one actively is associated with a research park.

In this process, an instrumental change in our context is that the mandate for academic institutions has recently been adapted. Proposition 40: (2001-2002): § 2 nr. 4 effectively extends the mandate for academic institutions to include a dissemination of scientific methods and results to the wider society including public administration and, more to the point, the business sector. In the changing situation, all entities are focusing harder on building up their research capabilities and reputations, not least through public support initiatives. Perhaps the best indication of existing or nascent research capabilities is that sixteen academic institutions currently have formal liaisons with FORNY, the publicly-financed program designed to facilitate the commercialization of research activities.

Public R&D System Structure

In the interest of cross-country comparison, certain structural aspects of the Norwegian innovation system should be highlighted. The organizational structure of what can be called the innovation infrastructure of Norway is depicted in the policy-centered organisational map of the Norwegian system of innovation found in the annex. With reference to this figure, six functions that take place within the frame of the innovation infrastructure can be distinguished. These include policy formulation and coordination, the instrumental support structure (of R&D), and the performance of R&D (the university sector, the institute sector, and the private sector generally).

[24] "Vitenskapelige høgskoler": These include the Agricultural University of Norway, Norwegian College of Veterinary Medicine, Norwegian College of Physical Education and Sport, Norwegian School of Economics and Business Administration (private), Norwegian State Academy of Music, and the Oslo College of Architecture.

Whereas the latter was presented in section 2, the first two aspects will be reviewed in this section in as far as they reflect on the U-SME relationship.

Policy formulation and coordination: regulatory factors shaping U-SME interaction

The principal elements of the policy framework that bear on the university-industry relations are rooted in the Ministry of Trade and Industry (NHD) and the Ministry of Education and Research. (UFD) These ministries, and their affiliated agencies, reflect either side of the U-SME relationship. The Ministry of Local Government and Regional Development (KRD) also plays a supporting role in our context since the U-SME relationship has an important regional dimension in Norway. The regional dimension is important as both the university-colleges and the SME sector are well represented in the districts: promoting dynamics among them is therefore seen as important to regional development.

The NHD is responsible for SME policy. In fact, a titular objective of the Ministry of Industry and Trade[25] is to improve the lot of SMEs. In 2001, this activity resulted in an Action Plan for Small Companies[26] with the explicit goal of stimulating research, competence-building, and innovation collaboration in small firms. (viz. Action Plan, 4.2) More instrumentally, it is completely or significantly responsible for several central agencies, including major responsibility for the Research Council, the Industrial and Regional Development Fund (SND) the National Advisory Office for Inventors (SVO), the Trade Council, and the Patent Office. Moreover, NHD is also the center of technology policy in the country and a lead actor in the drive towards an

[25] "The prime responsibility of the Ministry of Trade and Industry is to create a proper framework for Norwegian industry, the business community and the SMEs, to be innovative and competitive within the global knowledge economy."
[26] See http://odin.dep.no/nhd/norsk/publ/handlingsplaner/024071-990013/index-dok000-b-f-a.html

integrated innovation policy. It has sponsored several select-committees to develop relevant policy-initiatives, including the Hervik-Committee.

The Ministry of Education and Research (UFD) represents the academic research side of the equation. The UFD holds responsibility for the university sector. The university sector is still in the midst of a process of transformation and consolidation. In this process, the legal status of institutions of higher learning is currently under review.[27] In addition to general responsibility for the university sector, UFD contributes substantial funding to the Norwegian Research Council, and is currently active in contributing to shape Norway's integrated innovation policy. More to the point in the present context, UFD has been actively responsible both in extending the role of universities to encompass promoting the application of their research to wider society— especially industry[28]; and the proposition changing the title/ownership to university research results[29]. During the late 1990s, UFD sponsored a set of instrumental select-committees on commercialization of academic research issues (principally Bernt[30] and Ringnes[31] Committees) which ultimately led to the new legislation.[32]

[27] Ryssdal Select committee (December 2002) forthcoming in September 2003: this Greenbook will propose ways to harmonize the legal status of private and public institutions of higher learning. Implications for the way the state can influence/control these institutions. Discussion of the legal status of these institutions, with ramifications for the autonomy of the institutions involved

[28] Amendment of the University law (UFD- Ot.prp. 40(2001-2002)

[29] Amendment to Employment law (UFD - Ot.prp. nr. 67 (2001-2002)

[30] Bernt-utvalget (NOU 2001: From Insight to Industry: commercialization of research results from unviersities and colleges ("Fra innsikt til industri: kommersialisering av forskningsresultater ved universiteter og høgskoler".

[31] "IPR-Committee", on specific legal considerations of changing IP title at universities.

[32] See St. meld. nr. 39 (1998 -99) Forsking ved et tidsskille. See also Mjøs-utvalgets innstilling, NOU 2000: 14 Frihet med ansvar, Om høgre utdanning og forskning i Norge; St.meld. nr. 27 (2000-2001) Gjør din plikt - Krev din rett, Kvalitetsreform av høyere utdanning, and St.meld. nr. 35 (2001-2002) Kvalitetsreformen Om rekruttering til undervisnings- og forskerstillinger i universitets- og høyskolesektoren.

Major issues and directions in the policy-discussion

The White-Paper (UFD - Ot.prp. nr. 67 (2001-2002)) sums up many of the issues that have been raised in recent discussions about commercializing academic research in Norway.[33] This discussion has featured such topics as the changing boundaries between public and private knowledge, as well as the emergence of hybrid knowledge-based networks that source and exploit knowledge in entirely novel ways. The discussion has often explicitly been taken from international sources, in which references to adaptations in the US have been prominent but not exclusive (on Bayh-Dole, cf. Mowery et al.). There has been a notable recognition of the applicability of the experience of other Nordic countries.

The focus is however geared to national policy considerations. The discussion notes that public investments in research and education are high (see below) and takes the position that the research results of the country's academic institutions hold unrealized potential for application in industry. It makes the industrial transformation argument, saying that increasing the application of academic research can help develop the sustainable activities that can help reduce dependency on oil. In this context, the policy intention is to improve the conditions for knowledge/research-based industry, and to strengthen knowledge transfer.[34]

The legal amendment hopes to increase commercial utilization of academy-based inventions. An important point is that it intends to do so while maintaining the academy's traditional goals, namely free-research and higher education. In fact, its intention is to strengthen the traditional goal of universities in spreading research results to society. To do so, the amendment substantially readdresses the role of

[33] These discussions have included theoretical and policy discussions, and ranged from public documents, research reports, letters to the editor and conference activity. It became especially active from about the mid-1990s. See references for important components of this discussion.
[34] The White Paper cites that only about a fifth of the 4.4. BNOK of R&D services involved public research organization.

academic research. It widens the interpretation of the university sector's obligation to disseminate research results[35] to include commercialization as a channel for such dissemination. In order to do this the amendment changes the right to industrial application/commercialization of 'inventions' formally from the researcher to the university sector institution.

The amendment is designed to confront the researcher with a clearer choice whether an invention should be patented as well published (or in addition to publication: see case 3). This intention is based on the perceived need to increase knowledge transfer between academy and industry, and thus provide society as a whole with more of the returns from the activities of universities and colleges. In this context, the White-Paper points out that this is not only a job for the researchers themselves, nor only for their faculties or universities. It is also a job for industry. This is also an important implication: the amendment places responsibility on Norwegian companies to utilize and further develop new knowledge from the university sector. It emphasizes that the active participation of the institutions in the commercialization is important, as is the adaptation of the legal and regulatory framework to facilitate this.

Several currents of the previous policy discussion[36] are reflected to varying degrees in the new regulation. These include that:

- commercialization should be seen as part of the university's obligation to spread knowledge
- academic institutions should be positive to commercialization
- academic institutions ought to have a professional apparatus to promote commercialization: There is a need for intra mural support structures to promote better commercial application of patentable inventions.

[35] Universitets og høgskolelov: §2.
[36] Most notably: St. meld. nr 39 (1998-99) Forskning ved et tidsskille. (The Reserach White Paper),

- The researcher and the institution should have a right to share equitably in potential profits arising from commercialization[37]
- The researcher should maintain the right to publish
- Commercialization should not undermine the long-term goals of the university
- The research and the wider research community decide what to research and how, and how the results should be presented.
- Any "added value" from commercialization should not be used to finance other aspects of the institution's activities would be seen as principally suspicious.
- And, that other arrangements can be made on a bilateral basis between institution and researcher.

The change introduces new obligations on the researcher and the university sector institution. In the new environment, researchers are obligated to orient the university about results with potential industrial application ('notification obligation'). An obligation has been created at university sector institutions for active engagement in commercialization. The changing regime raises new questions and challenges. These include:

- The question of the right to publish, and who has responsibility in cases where more than one researcher is involved.
- The need to develop strategies whereby the researcher is able/encouraged to participate in commercializing ('working') the invention.
- How to introduce the obligation to notify on researchers who are not principally aware of, nor sensitized to what is patentable etc.
- The importance of introducing necessity that it act as the researcher's partner not opponent
- The need to better understand the empirical effect of the changing regime.

[37] The provision of a 'reasonable compensation' (in the Arbeidstakeroppfinnelsesloven i lov av l7.april 1970 nr.21: § 7) has been interpreted to mean a 3 way split of equal amounts to the researcher, his institute and the university. (with reference to the University of Copenhagen)

The support-structure: Institutional factors shaping the U-SME link

The operative agents and agencies at the level beneath the ministries are instrumental in our context. Over time, the support structure has developed a set of institutions, programs and services that are designed to promote greater societal benefits (especially economical) from academic research. The support structure basically combines funding with advice. It includes the public and semi-public agencies, research parks and incubators, venture capitalists, etc. The functional division of labor of this support-structure can be broken down into financing and advisory agencies and their programs, the organization of research parks and incubators, as well as important basic agencies like the Norwegian Patent Office.

Public Financing and advisory agencies

The financing and advisory agencies immediately beneath the ministries are centerpieces of the Norwegian System of Innovation. The two main national bodies, which are designed to fill complementary roles, are the Research Council (NFR) and the Industrial and Regional Development Fund (SND). These are major institutions that provide funding and advisory services for start-ups, existing enterprises as well as university and institutionally-based research. They are central to the public-efforts to support new knowledge in Norway, and their networks shoot through the rest of the system. Both NFR and SND target SMEs in their research programs. Direct policy measures that involve the U-SME relationship are rooted in these two agencies. They (co)sponsor the two pillars of the policy-initiatives directed at academic research and SMEs: namely MOBI and FORNY (see the policy-instruments section below).

The Research Council is a central funding agency both for university and private-sector research. Although its role in promoting the generation of new knowledge may be considerable, its direct role in the IP-system is much less

pronounced. The number of patents reported on research funded by the Industry and Energy section of NFR grew rapidly in 2000. The raw applications jumped 120% from a cumulative total of 92 in the period till 1999, to 201 in 2000. Through its programs, the Research Council emphasizes the commercialization of research results. It is a cosponsor and the coordinator of the FORNY program (with SND), which is the spearhead of Norway's efforts to promote the commercialization of academic research.

The Industrial and Regional Development Fund (SND), which is undergoing a reorientation today, is the mainstay of Norwegian public funding for industrial development. It was established in 1993 on the basis of several previous funds, including the Small-Firm fund (Småbedriftsfondet). The SND offers enterprises and independent agents an array of instruments, which, in sum, combine funding and advisory services. Support is offered on a general basis both to entrepreneurs involved in starting up a new enterprise or to those developing an existence enterprise. Proposals that involve innovation, competence building, environment, and internationalization are especially welcomed. This role is supplemented by the Industrial Development Corporation. (SIVA) In 2001 SND's Entrepreneurship Center reported that, of SND's 16,000 users nationally, 90% are small and medium-sized enterprises. In general, about a tenth of the small firms themselves have integrated patenting into their business strategies. SND provides advice to applicants on intellectual property rights and hosts a set of relevant instruments.[38]

There is also a set of much smaller organizations with more specific mandates and lesser public funding. Several of the agencies are spread throughout the country, especially in the larger cities. For example, SND has regional offices and is

[38] See section 3.2: these include the OFU/IFU-ordningen, Start-up with new technology (ENT), NT, FRAM, BIT, Kultur og næring, Regional omstilling. It is also a co-sponsor of the FORNY program.

developing a local presence in the districts as well (Fylker). Here we can highlight the National Advisory Office for Inventors (SVO). National Advisory Office for Inventors offers a range of services, from the preliminary evaluation of the inventor's idea, to market surveys; from help in navigating the public support system, to help in locating partners. It receives on the order of 1000 applications per year, of which roughly half are considered more closely. Between 100 and 150 of these projects are then pursued. This means that its role is in many cases primarily advisory rather than financial. Only a small percentage of these (under 5%) can be traced directly to the university sector.

Publicly funded Investment Companies

A current tendency in the Norwegian national system is the attempt to marry public and private capital to promote start-ups or fledgling enterprises. These cater specifically to knowledge-based companies at early phases when IP strategy is most important. The START-Fund (http://www.startfondet.no/about/) is the result of a relatively recent joint initiative between public and private interests. The Fund is a registered company (ASA) that provides risk-capital and advisory services to start-up companies. The Fund's capital-base is relatively large (compare that of SVO) at NOK 320 million, half of which is financed by private investors and half through guaranteed loans from the SND. Today it has 18 shareholders. Like many venture companies, it targets companies in rapidly changing areas with international growth potential, especially biotech and ICT start-ups. However, its focus group is somewhat wider than that, and it opens for a, "wide variety of profitable, competence-based companies capable of creating value in Norway.[39]

[39] see http://www.startfondet.no/english/

Argentum is a risk-tolerant investment company co-owned by SIVA and SND. Its public endowment is of the order of 2.45 Billion NOK. This investment fund will be independent, and more than 50% of its stock will be privately held. Its intention is to provide longer-term financing for innovative companies. The new company is apparently not directed at startups, although it is not immediately clear how it will in practice complement the existing range of (semi-) public activity directed at financing and advising innovative activity in the private sector.

Research Parks and affiliated incubators

The Corporation for Industrial Growth (SIVA) is a state-owned, independently operated innovation hub with a long and varied history. The 60 innovation centers that SIVA is involved in are designed to bring together commercial, financial, and R&D. These include the build up of 12 research parks from the mid 1980s until today (http://www.fin.no). Norwegian research parks offer a range of services including seed-capital, research facilities, and advisory services, especially concerning licensing. They are partially publicly supported especially to promote the commercialization of university-based research. The FORNY Program, administered by the Research Council, funds eight research parks in different parts of the country.

Norwegian Patent Office (NPO)

In Norway, the Norwegian Patent Office (NPO) is in many cases the first point of contact between the SMEs and the IP-system. The NPO is an agency under the Ministry of Trade and Industry with responsibility for patents, design, and trademarks/collective rights. It administers the application and grant processes for these rights, and it is responsible for their publication as well.

In order to encourage smaller enterprises to patent the Ministry reduced of application fees in 2000. [40] This measure stipulates a 20% reduction in the application fee (to NOK 800) for enterprises of 20 employees or less, including independent applicants.[41] In addition, this applicant group will be exempt from the examination fee (NOK 2000) that was recently implemented. The examination-fee will affect medium-sized companies, but will be refunded in all cases should the application be withdrawn.

A changing environment

The innovation infrastructure is currently undergoing a series of important changes that will have significant consequences for the way U-SME relationships are promoted. The move towards an "Integrated Innovation Policy" already mentioned involves several of the ministries and their agencies, principally the Ministry of Industry and Trade (NHD).[42] There are several agencies that are instrumental to the commercialization of academic research that are involved in this process of consolidation: these include the Research Council (NRC), the Industrial and Regional Development Fund (SND), National Advisory Office for Inventors (SVO), and the Trade Council.[43] According to recent reports, the latter three agencies are to be merged into a single innovation and internationalization entity that will "make it easier for entrepreneurs" (DN, 28.03.03: Gjør det lettere for gründere).

[40] kgl.res. 7 april 2000 for endring av forskrift vedrørende avgifter for Patetstyret
[41] The majority of applicants, see below. Note that the fee-schedule for patent applications has been considerably lower than, say, the Danish. In the new system, the combination of the application and the examination fee will, for large enterprises rise to NOK, which is the on par with the Danish. The combined fee for small and independent applicants will at the same time sink to NOK 800.
[42] Cf. http://odin.dep.no/nhd/norsk/p30000694/index-b-n-a.html for a status report.
[43] Note the Trade Council's activity related to the commercialization of academic research.

Policy initiatives to stimulate commercialization of research results

In Norway, an array of policy instruments affects SME-university interactions more or less directly. The intention, the effect, and the sponsorship of these mechanisms—and their associated infrastructure—are quite diverse. This section takes stock of the mechanisms that most deeply and most directly affect SME-university interaction in Norway.

Structural measures to adapt academic research to commercial needs: Foundations

Several broad aspects of the Norwegian innovation system effectively lay the foundation for academy-industry relationships. Three general elements of the Norwegian architecture presented in the institutional-factors section (2.2), are emphasized here.

A principal corner-stone of the U-I relationship is Norway's particularly large institute sector. The Norwegian institute sector[44] is very broad and diverse, with over 100 institutions reporting R&D activity. Beginning in the post-war era, the build-up of this unique institute-sector can be seen as a policy-measure designed to promote and guide industrial-renewal by linking to the activities of public research organizations to traditional enterprises.[45] Today, public research organizations increasingly develop

[44] A total of 128 institutes of different descriptions receive public support. According to the R&D Survey (above), 114 conducted formal R&D. Eight institutes are research laboratories or agencies are operated and fully funded by the government. The majority are research organizations that receive a significant share of their total funding from public sources. Many of the others are small stand alone entities, although several are large even in European comparisons. Two of the large entities have several affiliated organizations which might be companies with majority control residing with the parent organizations. Many increasingly have significant private funding and look upon themselves as free-agents (not 'public').

[45] Sintef is an early and very large example. It was built up to promote links with the private sector early in the post war technocratic environment. The original premise can be characterized by a technology push policy, where large existing companies were targeted for renewal. It originally had and continues to have expressed links with NTH (now NTNU).

their own technology-transfer activities (e.g. SINVENT AS, 215MNOK in turnover) and/or utilize the support structure offices (FORNY).

A second corner-stone is the changing public funding-environment. One dimension, already emphasized, is the current primacy of the two principal funding agencies: the Research Council (NFR) and the Industrail and Regional Development Fund (SND). These central funding agencies together provide the basis for the two central pillars for supporting SME-academy interaction in Norway. (MOBI and FORNY: see below) Another dimension to highlight here involves the changes in the funding environment which have over the years brought academic and private-sector research together both as collaborators but also as competitors. This includes direct and indirect encouragement to collaborate (and compete) with industry research. This also involves explicit encouragement for Norwegian participants to participate in EU Framework projects, where innovation among SMEs is emphasized.

A third platform that provides the basis for U-SME collaboration is the build up of research parks, incubators, and business parks. This build up began during the mid-1980s under the auspices of SIVA (Corporation for Industrial Growth). SIVA is involved in 40 business parks, of which twelve are ‘research parks’ which receive partial FORNY funding. The research parks (and aligned incubators) are located near central public research organizations and offer a range of services. The parks offer research facilities, special conditions for localization, advisory services especially related to licensing, and in some cases some seed-capital. Research parks receive some public support and are designed to promote the commercialization of university-based research.

Specific strategic initiatives of the U-SME relationship: Pillars

In terms of specific initiatives, there are two major bridge-heads for the relationship between university research and SMEs. The MOBI ("Mobilizing R&D related innovation") program is the larger program with a proposed budget for 2003 of 26 MNOK. This program explicitly targets SMEs and involves initiatives to promote collaboration with R&D centers, not least universities and regional colleges. MOBI was originally known as BRIDGE (BRO), "Bridging the gap between Industry and Research". The change of name from BRIDGE to MOBI signals a changing orientation for this program, although it maintains its SME focus, its regional presence (TEFT attaches), and its attempt to coordinate different initiatives in the innovation system. The MOBI program has long been the mainstay for the relationship between university research and SMEs. This program has a long tradition, tracing beyond BRIDGE (1998-2001) to policy intitiatives from the 1980s that focused on the absorptive capabilities of small firms. [46]

MOBI's current portfolio includes measures to promote technology transfer between research-institutes and SMEs (TEFT), measures to promote mobility between (regional) colleges and SMEs, as well as more general measures to improve the position of colleges in regional clusters:

- TEFT: "Technology-transfer from research-institutes to SMEs (Teknologiformidling fra forskningsinstitutter til små og mellomstore bedrifter)[47]
- College-based initiatives with commercial target: (Næringsrettet Høgskolesatsing – nHS) Cooperation between SMEs and state colleges

[46] MOBI's legacy reaches back to the 1980s (cf. TEKNOVE), when KRD (at the time Kommunaldepartementet) initiated links between the research system and regional SMEs. Regional research foundations and competence systems were set up. Programs in the late 1980s included SMB-T, Idesøk,Verkstedprogrammet i Nord-Norge, SMB-U, NT-programmet, and BUNT osv. This involved public support initiatives designed to provide firms with advisory services and to improve their knowledge capacities.

[47] For an assessment of TEFT, see Remøe (1998).

- SME-College (SMB-H) – to strengthen state colleges and their contribution to regional innovation (see also SME Competence)
- Regional Innovation Regionale Innovasjonspiloter: a joint venture between NRC and SND. Instruments contribute to building regional innovation-systems and clusters.
- The publication of SMB-revyen. (since 1993) about cases of SMEs who have received support.

The focal point of Norway's commercialization of academic research activity efforts is the FORNY Program (FORskningsbasert NYskaping: "Research-Based innovation and start-ups"). FORNY (=Renew) has a proposed budget for 2003 of 15 MNOK. It represents a cooperative effort between SND and NFR. It was originally part of the BRIDGE umbrella of measures and it links relevant commercialization efforts (funding and advice) to activities found in existing regional research parks.

FORNY was established (1995[48]) with the objective of stimulating public research organizations (the university sector as well as institute sector) to greater value-creation in Norway in the form of start-ups/spin-offs and licensing arrangements with industry, irrespective of company-size. The FORNY program promotes (and assists) the generation of new ideas in university sector institutions, it helps the research explore the marketability of the idea, and it assists during commercialization through its technology transfer offices.

The program was originally intended to become self-financing already in its fifth year. This intention turned out to be unrealistic[49], as previous experiences in other countries would suggest. In general, the program provides resources to promote technology transfer advisory functions at public research organizations (infrastrukturmidler). It also provides financial support for the commercialization of

[48] Initiated by NFR and SND, its original funding (95 MNOK) came from NFR, SND, KAD, NHD.
[49] In 1997, royalites were at about 3 MNOK. See Hervik et al. (1997).

individual ideas from the university sector (incentivmidler: NOK 200.000). In its second iteration, FORNY II (2002-2009) has been strengthened. Since the advent of the regulatory changes addressed above, it has become the signal-bearer for increased commercialization from the university sector. The FORNY budget has been increased for fiscal 2003 including funds earmarked to aid universities in improving organizations according to the new law. The current FORNY program has subsumed the program of Industrial development from Medical Research (2002) and has generally increased attention to biotechnological research. It is currently planning to expand operations to include supporting the commercialization of R&D from public and private companies.

In Norway, there has thus been a legacy of measures (e.g. Bridge, Teft, Bunt) to promote links between SMEs and public research knowledge-bases. This legacy remains most visible in the comprehensive MOBI program. More recently, policy focus has turned towards crystallizing new companies and/or facilitating licensing from public research organizations. This tendency has been closely linked to the build-out of an extensive set of research parks/incubators during the 1990s. This direction of policy activity has been directly linked to the development of the FORNY program which has developed a regional net of technology transfer offices within these research parks. The current focus is now moving from the commercialization of public research to a more general focus on assisting the commercialization of all types of research.

Other initiatives that target relevant issues: Buttresses

FORNY and MOBI therefore are intended to come at the U-SME relationship from the two ends: FORNY in funding the establishment of spin-offs or start-ups based on academic research and MOBI on existing SMEs. In addition, these funding

mechanisms are designed to complement a list of other public financing instruments that support different phases of newly established or establishing companies, not least that of the seed-capital/risk capital funds.

A set of other instruments also provide significant support to improving U-SME collaboration.

These include the following instruments linked to the SND:

- New bonus support (linked to FORNY) for entrepreneurs targeting public research organizations in the areas of Marine Biotechnology and biochemical engineering. (total 1 MNOK)
- Innovation and technology-program in Northern Norway (Nyskapnings- og Teknologiprogrammet i Nord-Norge: NT-programmet) 'to contribute to increased innovation in new and existing technology companies in Northern Norway' (24 MNOK in 2003). This program includes fellowships to link University sector researcher to SMEs.
- Public Research and Development Contracts (OFU) and Industry Research and Development Contracts (IFU) support R&D collaboration with public sector and private sector entities respectively.
- VINN is a private consulting and contract R & D institute supported by SND that offers services in the fields of technology, competence and information for industry and the public sector.
- InnoMed: National Center for innovation support and industrial development in the Health Sciences.[50] This regional network is based in large public research organizations (Sintef Unimed, Medinnova, Norut Medisin og Helse). It is designed to focus and coordinate research in order to adapt solutions for the (public) procurement of health services. It provides testing services, facilitates contact, and acts as a coordinating device to the public financing of relevant projects (from SND, Eksportråd, NRC, SVO).
- Medinnova SF (est. 1986) is designed to coordinate U-I collaborations involving the national hospital, Rikshospitalet. It presents itself (http://www.medinnova.no/norsk.htm) as bridge-builder between research and commercialization of healthcare technologies, and offers a range of services

[50] Nasjonalt senter for innovasjonsbistand og næringsutvikling i helsesektoren

under the headings of technology transfer (Assessment of market and commercial potential, Intellectual property rights, Product development, Partnering, Management of licensing deals, Formation of companies, Business plan development), research collaboration ("Medinnova promotes and administers all kinds of research collaboration like clinical research, laboratory research and animal experiments"), funding administration, and networking and links.

- SIMULA Research Laboratory (est 2001): Adapting 'basic research' in information and communication technologies to business ideas. Pledges of public funding totalling 250 MNOK for a five-year period. One of its areas of activities is an organizational model (EFFEKT) for the commercialization among public research organizations.
- The Business at School Initiatives (Næringsliv i Skolen) involving the confederation of companies (NHO), universities and public and private sponsors. This is an umbrella for a variety of initiatives including Gründerskolen ("Gründerskolen", a nationally recognized course in entrepreneurship (10 credits), Young Leadership (Ungt Entrerpenørskap), and Venture Cup, a competition in designing a business-plan.

Case studies and existing academy-industry link indicators

This section addresses the difficulty one faces when collecting reliable information about the current degree and extent of the relationship between academic research and small and middle-sized enterprises in Norway. In it, we first assemble existing empirical evidence about academy-industry links. In the second part, we survey four case-studies in order to try to identify some current concerns and problems in the U-SME relationship.

Existing empirical evidence

The ability to identify university-industry interaction has until now been severely limited. The patent-record would be a natural avenue to study the commercialization of academic research. However, because inventors have been entitled to all rights

from their research, academic patents have not been readily identifiable. The change in the employment law entitling the universities to patent-rights will, when it is fully in effect, have the advantage that academic patents will become more visible both for researchers but also for small and medium-sized enterprises who use patenting as a way to identify potential partners in academia.

Evidence from Patent Data

Given this situation, Table 2.3 attempts to identify academic patents by using information in the names and addresses of applicants in domestic Norwegian patents during the 1990s. This gives a preliminary (=incomplete) sketch of patenting activity at some research parks (the research park is listed as an applicant) and (more incomplete) of universities.[51] This first look indicates a lower bound of 129 patents, suggesting that at least 1% of Norwegian patents involve the university sector and/or companies at research parks. The major lesson is that reliable information is lacking about current and past academic patenting and that it should be improved in light of the changing regulatory environment.

Table 2.3: Norwegian patent applications (1990s) by type of applicant (N=12,852)

APPLICANT IDENTIFIERS	Total
BANKS	2
COMPANIES	3658
CO-OPS ETC	35
CORPORATIONS	2067
GOVERNMENT	7
INDIVIDUAL	6692
INSTITUTES AND FOUNDATIONS	207
IP PROFESSIONALS	34
PUBLIC CORPORATIONS	21
RESEARCH PARKS	89
UNIVERSITIES	40
Grand Total	12852

Source: SINTEF-STEP

[51] The patenting of other public research organizations are indicated here, and can be verified using records kept by NIFU.

Evidence from Research Parks

Table 2.4 provides an additional indication of the interface between university research and new firms, by enumerating firms located at established research parks in 2000. The firms are all SMEs, although not all are necessarily research oriented let alone products of nearby academic research institutions. However, it is fair to assume that a majority are research oriented and benefit specifically from proximity to university research environments. [52]

Table 2.4: Number of active companies in 7 research parks, 2000. (N=236)

Research Park	Total
OSLO RESEARCH PARK LTD	55
TROMSØ RESEARCH PARK LTD	19
BIOPARKEN LTD	19
BERGEN HIGH-TECHNOLOGY CENTER, (SARSIA INNOVATION AS)	18
LEIF ERIKSSON NYFOTEK LTD, TRONDHEIM	26
ROGALAND SCIENCE PARK, ROGALAND	47
CAMPUS KJELLER LTD	15
TRONDHEIM INNOVATION CENTRE LTD. (TECHNOSTALLEN AS)	37
Grand Total	236

Source: SINTEF/Thomas Halvorsen

The activity reflected by research parks is high, a fact that comes through in the OECD survey (below) where the number of spin-offs in Norway is uncommonly high in international comparisons. Another indication of research park activity (which is also a reflection of colleges trying to establish themselves as university candidates) is that they continue to multiply: Today, there are twelve research parks, including Lillehammer Knowledge Park Ltd., Sørlandets Teknologisenter Ltd., IT Fornebu, and Research Park, Narvik.

Evidence from the FORNY Program

The instrumental FORNY program, which is one of two policy-instrumental pillars promoting U-SME relations in Norway, also provides valuable insight into the current

[52] For a survey of the economic viability of firms, see Halvorsen, 2001.

extent and depth of the link. The FORNY offices are located in the research parks, so that their reports can be read in light of the above. In its first manifestation, FORNY reported a total budget of 178 MNOK for the period 1995-2000. For the same period the program reported involvement in approximately 1,500 business ideas. Of these, 232 were reported to have been commercialized: about 130 through spinoffs/startups and over 100 license-arrangements.[53] This would tend to indicate, assuming that start-ups do locate at the research parks, that approximately half of the tenants at the research parks represent a founding link with universities.

One relevant example is Leif Eiriksson Nyfotek (LEN), which caters to the environment surrounding the Technical University and SINTEF in Trondheim. It promotes licensing of the ideas from universities and institutes in Middle Norway. In addition, it claims (2000, interview) to have spun off roughly 40 companies, of which seven involved patents.

Evidence from a recent OECD survey

The picture of U-SME interaction in Norway has been significantly improved by a survey recently conducted as a part of the OECD study on *The Strategic Use of Intellectual Property by Public Research Organisations in OECD Countries*[54]. The survey covered a total of 34 offices involved in some form of commercialization of results from public research organizations.[55]

This study confirms that technology transfer and IP management activities remain relatively informal in Norway. Few of the offices had more than one full time employee, suggesting that (as of 2001) a total of 38 man-years (i.e. fulltime

[53] FORNY's objectives for 2002, include identifying 300 research-based commercial ideas, 50 licenses or start-ups. FORNY estimates that this would generate 400 MNOK in the form of turn-over, R&D expenditure, and sale of startups or licenses.
[54] DSTI/STP(2002)42/Rev1
[55] that is: research performing universities, research laboratories and other research organisations that receive a significant share of their total funding from public sources.

equivalents) are devoted to technology transfer activities in Norway. In most cases technology transfer is not a formalized role (consisting of an office or division) of Norwegian public research organizations. Only one in five respondents reported being dedicated to the technology transfer from/to his host public research organization. Universities and colleges, including university hospitals, figure prominently as the home of the research in question.

Much of the technology transfer activity in Norway is involved in research agreements with firms. Only a little over half of the technology transfer offices apply for patents. In most of the reported cases, the institution retains some ownership claims while in half the reported cases so does the researcher. In about a forty percent of the cases the funder and/or the government is said to hold rights. The respondents represent different size-classes of R&D activity as measured by expenditure.

In terms of patenting and licensing at public research organizations in Norway, one third of the actors report having active patent portfolios. These portfolios range in size from 1 to 34 patents in all, yielding a total of 114 patents reported to be in force. Twenty-eight patents were granted (mostly in Norway) in the previous year, while ten respondents reported applying for a total of 43 patents in that same year.

Table 2.5. PRO patent applications in 2001: technical orientation (N=43)

Recent applications	Number	%
Health/pharmaceuticals	5	11,6
Food/Agro industry	7	16,3
IT, electronics, instruments	6	14,0
Production technology, new materials	10	23,3
Energy, environment, transportation	14	32,6
Fishing technology	1	2,3
Total	43	100,0

Source: Iversen (2002)

Licensing activity was modest. Twenty-two licenses were granted in the previous year (2001) Mostly on the basis of some sort of exclusivity. The important aspect to note in our context is that most licensing activity involved "SMEs". [56] Fourteen were licensed to this size-class while eight licenses were granted to larger firms. Licensees were both foreign and domestic.

A considerable number of spin-offs and start-ups were reported to be generated by a small number of respondents. Six respondents report the generation of a total of 39 spin-offs and 28 start-ups were reported by 11 respondents (these may overlap). This result is comparatively high in the OECD survey. We note the risk of double-counting in this exercise.

Four illustrative cases

Four cases were chosen to illustrate different aspects of the SME-university sector relationship in Norway and the involvement of the support structure. The four cases are taken from four different regional and academic environments. Three of the cases are associated with universities (Oslo, Trondheim, Bergen) while the forth came out of a degree project from one of the university-colleges. The initial and the continual involvement of the academic institution(s) vary as to level and intensity. In addition to a degree project in which the advisor is co-submitter of the patent (case 2), the cases include situations in which the founder no longer works in the academic institution but maintains active links to universities via a scientific board (case 1), situations in which the professor has reduced his work-load at the university in order to lead the company while recruiting actively from the university (case 3), and situations in which different professors have maintained their post while working at the company (case 4).

[56] although the size-class was defined at less than 500 employees.

CASE 1: A start-up based on degree-project at science-college

Basics: Case 1 illustrates an attempt by a graduate student to commercialize the research results of a degree-project at a science college. The company is developing a method to remove predators from shellfish sea-farms involving an environmentally-friendly coating. The company was established 2000 upon completion of degree at the Agricultural University of Norway (south of Oslo). The graduate is the only employee. This company is presently located at the regional incubator/research park (the Aas BioScience Park Ltd) associated with the college. It is working towards a functional prototype.

Link with the university sector: Company1 represents a continuation of thesis-work in engineering. This is a case where the graduate and his advisor are co-applicants on the company's single patent (2002). The advisor continues to contribute to the partnership, although at arm's length. The start-up is currently located at the college's incubator, but intends to move closer to potential collaborators and/or customers. The incubator offers some advisory functions.

Patenting and the importance of the support-structure: Company1 also represents a case of a commercialization that, for different reasons, has not utilized the main channel for public support. Instead, it has been referred through the National Advisory Office for Inventors, which provided Inventor-Fellowship support and covered patent-costs. It is currently aiming to develop the idea through a partnership contract (Industry Research and Development Contract from SND). It is negotiating an agreement with a sea-farm and intends to move out of the research park incubator which is not close enough to market. The decision to patent was made on the basis of advice and earmarked funds.

CASE 2: SME with international presence and strategy

Basics: Company2 is an antibody therapeutic company that was founded in 1996-7 by a Norwegian molecular biologist in conjunction with a German academic team. Its area of specialization involves methods to screen for and target human antibodies. It currently employs 25 "scientists and business professionals" and has a growing range of product-services.

Link with the university sector: This small firm grew up in the incubator of a science park (Oslo Research Park, adjacent to the University of Oslo and the Norwegian National Hospital) where it is still centred: it has utilized the Park's IP office for certain licensing purposes. Its research, its market strategy, and its presence are however international. It maintains active contact with university environments both domestic and foreign. It collaborates nationally with public research organizations, and has (had) an international strategy and presence. Contacts with national academic research have been maintained principally through its international three-member scientific advisory board.[57] Recently, the formal links represented by this board have been loosened in favour of more ad hoc relationships.

IPR issues: An active intellectual property strategy is central to the firm's strategy, and it has actively sought to acquire access to markets and complimentary technologies through acquisitions as well as through partnerships with other biopharmaceutical companies and research institutions. According to reports, Company2 leveraged part of its business idea on the fact that a competitor did not patent in Norway (Norway was a 'loophole' because it was outside the European Patent Convention). It has an active international strategy in which IPRs are primary in terms of acquisition or partnering with outside knowledge bases. The company has a number of active patent-families internationally and is relatively neutral to potential

[57] This board included prominent university researchers from Norway, Germany, and Australia.

changes in patent regulation. (cf. in terms of the Biotech Directive or in terms of Norway's formal relationship to the European Patent Office)

Links with the support-structure: Company2 has been supported by the Norwegian support system. It is located in a science park (Oslo Research Park, adjacent to the University of Oslo and the Norwegian National Hospital), on whose board the founding CEO now sits. The company's co-founder and chairman is actively involved in advocacy and other roles with the support-structure, including prominent positions at the Norwegian Bio-industry Association, the Oslo Research Park, and as a member of the Research Board for Medicine and Health at the Norwegian Research Council. Company2 notes a need to adjust the support-structure in order to cater to the special needs of life-science research. In the company's view, there are special reasons to dedicate increased resources to research and development activities in this field that are geared to the longer time-horizons implied by this activity.

CASE 3: Spin-off from contract research: New technology in existing applications

Basics: Case 3 originated from project work in the Norwegian Universtity of Tecnology and Science (NTNU) environment in Trondheim in the mid 1990s. It was formally established as a company in 1996 and reported its first commercial sale in 2000. There are 11 employees. This company effectively grew out of contract-research for an SME (1994) to produce a light generator. Today the company addresses the 'low tech' field of electrical generators by 'high tech' means, in order to cater to several specific needs such as deep water power generation. Company3 works on 'smart' integrated solution involving motors, electonics and electronic control. One product is a propulsion system for wheel-chairs.

Link with the university sector: Company3 effectively came out of project-work at the NTNU Department of Electrical Power Engineering. Several of the active participants, including a founding member, maintain positions at the university as professors. Others have been recruited from different areas of the university where the link has been maintained through a framework agreement. Company3 was also aided by the contributions of a retired professor and benefited from support from parts of the SINTEF system (Depts. Production Engineering and Materials Technology). The company has also pursued a policy of involving students in its work.

Links with the support-structure: The nearly ten year old company is currently located outside the research park in Trondheim. It has received substantial support from some Research Council grants. It was co-owned by NYFOTEK, a Trondheim research park. A notable aspect of Company3's development is the support from the faculty at the university itself, which reportedly acted as a midwife and incubator unit for the company. It does not appear to patent.

CASE 4: Spin-off in Bergen

Basics: Case 4 involves a firm that in 1996 spun out of marine-biology research in Bergen. The technology allows for the testing of environmental pollution using biochemical markers. It represents a case where both the local environment (the university and formative support structure) together with a range of public support structures have actively contributed. It is located in the regional science park, but maintains a wide platform for international collaboration. It currently has 16 employees, including the founder. Different arrangements have been made to connect it with its immediate academic environment.

Link with the university sector: Company4 involves many recruits from the university. PhD fellows have also been linked to the work of the firm. The lead figure

has reduced his position at the university in order to direct the company. Different arrangements have been made to connect it with its immediate academic environment. The company involves many recruits from the university. The company involves many recruits from the university. It collaborates widely internationally, including with international universities. Professor, Institute for Molecular Biology, University of Bergen (working 20% at university): 10 scientists, most from University of Bergen but also the University of Oslo.

Links with the support-structure: Company4 has extensive links with the support structure. It is located in the High-Technology Centre (HIB), a Science Park in Bergen. It has received financial support from the KAPBIO Program (Research Council), including matching funds on an IPO; from the FORNY program, from the Start Fund (first project to be funded: 3 MNOK, from SND (IFU), and from EU Framework Programme. Other support that has been important has come from HIB, which has provided advisory services (e.g. on patenting), lab access, as well as flexible arrangements regarding professorial responsibilities at University of Bergen.

IPR Issues: Company4 emphasizes both patenting and publication and recognizes the need to find the resources for both. The company has consciously attempted to improve the IPR culture of academicians and has praised the valuable contribution from the technology transfer office (Forinnova), which as actively helped in patenting activities, including taking over another patent and in monitoring of relevant patents on the world market.

Concluding Policy Discussion

The policy-objective to improve the interaction between university research and SMEs proceeds from the recognition that several factors have actualized it. One important factor is the changing funding environment (cf. NOU 2001:11) that has

increasingly brought SMEs and academic researchers both into collaboration—and competition with one another.[58] In light of this development, it has become more important to promote interaction between academic and small firm research while avoiding direct competition that can have negative effects in the economy as a whole. This concern for symbiosis over competition/crowding-out is one important aspect which has been brought forward in the changing environment. It also helps to emphasize that the potential for increasing interaction bears with it the potential for increased competition as well as increased cooperation.

Another claim that has been raised is that the changing nature of certain research fields is making commercialization a more suitable way to disseminate research results than more traditional means (see emphasis in White-Paper). Publication can be interpreted to be an insufficient vehicle to spread ideas whose value is best developed by trying out different practical applications. In such cases which are generally associated with life-science and information technology, the incentive that commercialization represents to study such applications can be a more apt carrier for new ideas. There is however a flipside to the argument which also should be recognized, that is that commercialization is an avenue that is much more resource-intensive than the traditional channels of dissemination.

In this environment, the interaction between university research and SMEs entails a growing need to facilitate a mutually attractive division of labor between the parties. In it, it is important that both parties have something to contribute and that both receive commensurate benefit. This benefit need not be monetary. There are many forms for U-SME interaction, implying that policy measures must take into

[58] Developments on the funding side of research is one of a set of factors (viz Bayh-Dole Act in the US, 1980) that originally led to a more and more urgent questioning of how to deal with research results from private and public institutions on an equitable footing.

consideration very different needs. The type of division of labor that is most suitable may vary from case to case.

In general, interaction can take on several forms, including the following:

- Classical scenario: Ongoing academic research can lead to results with commercial potential: this potential can be realized through contractual (e.g. licensing) relationships with existing SMEs or it can lead to a new company (spin-off or start-up). This entails ways to identify the ideas with commercial potential and ways to link the idea with other types of entrepreneurial expertise such as funding, patent strategy etc.
- Publicly-funded joint-research: Collaborations between university and SMEs (for example in a grant situation) can lead to results with commercial potential. In this scenario, the partnering SME will generally spearhead the commercialization process with the continued participation of university environments. This entails mechanisms that allow for university researchers not only to participate in the conception of the idea, but also in its follow-up. (See the case study 3 and 4 for different arrangements)
- Contract-research and shared results: An SME can itself fund university research in order to address a concrete problem. This contract research may lead to a solution which has wider commercial potential. Mechanisms to deal with this eventuality will tend to be contract-based, along the same lines as above.
- Mobility. Researchers in one context can (on sabbatical etc) come to work in the other, producing results that have commercial application. Mechanisms to deal with this eventuality will also tend to be contract-based, where there may be an incentive to arrive at such results.

Concluding observations of the Norwegian case

Against this background, this report demonstrated that the state of U-SME links has been associated with two threads of Norwegian policy. The first thread caters to small and middle-sized enterprises and goes back to the 1980s. The second policy thread involves the commercialization of academic research, whose modern history starts in

the middle 1990s, but which extends back to earlier phases of Norwegian industrial policy. The report identified a set of current policy initiatives along this border.

Two policy instruments in particular were highlighted as the pillars of Norwegian policy to improve university-SME interaction. The MOBI-program and the FORNY program were shown as historically linked and, by intention, complementary. It was observed that MOBI's precursor (BRIDGE) represented an ongoing attempt to consolidate university-industry links specifically directed at new and existing SMEs. This tradition, which originally attempted to widen the field from that of R&D to other innovation activities, has since narrowed its focus to the link with existing SMEs, especially in the regions. At the same time, FORNY has been moved outside the MOBI framework (still as a collaborator) in order to focus on new establishments. In its second phase, FORNY has grown into a larger and more visible instrument to stimulate the commercialization of public research. It is currently working with the university sector to build up in-house competences for commercialization in line with White Paper recommendations and the new obligations for the university sector. Somewhat out of role, FORNY is also opening for commercialization of research from other sources than public research. (cf. 2002-2007 Plan)

In general, Norwegian support instruments can be said to provide a wide range of functions that affect the U-SME relationship. This review suggests that many of the relevant concerns in promoting U-SME collaboration are in place in the Norwegian support structure. Primarily the focus is on funding mixed with advisory function in the Norwegian case for different types of collaborations at different phases in development. There is an expressed intention that there should be an apparent diversity of instruments for financing start-ups, pre-start-ups, growing companies, and

existing companies actively interested in collaborating with the university sector. In addition, there are initiatives that address the need for locations near university centers, as well as the germination of initiatives to stimulate entrepreneurship, etc.

The review however has not provided the basis to say how well (=effective and efficient) the individual initiatives work, or how well they work together. Nor does it provide an adequate basis to draw conclusions on how well the support addresses the needs and concerns of those currently involved in U-SME interaction. The four case-stories are by and large positive about the role of the support structure, although complaints were heard (from experience or not) specifically about the high cost of borrowing from the funds, of the high costs of some research parks, and of a certain short-termism in the support-structure.

Policy challenges

As the report has demonstrated, Norway is now embarking on the next stage of how the innovation system can better facilitate fruitful and equitable partnerships between academic and industrial research. So far, Norway has focused on the question of making more out of the (disproportionately) large public investment in university sector research. It is now addressing how the institutional set-up can gear itself to the considerable challenge to commercialize academic research. At the same time, the country has set out to form an "integral innovation policy". In this work, policy should (continue to) link the question explicitly to assisting the country's large population of small and medium-sized companies.

By and large, the current policy concerns have been explicated in the Norwegian policy discussion in the run-up to the recent amendment.[59] As the report

[59] Notably in the White Paper (Ot Prop 67), and in different green-papers, principally the Bernt Select Committee Green Paper but also others, including the Ringnes Select Committee. Note that there has not been unanimity in the work of the committees.

has shown, these concerns have tended to revolve around the instrumental change in the question of title to patentable research results. This question is central to the university-industry relationship in general and, by extension, to the potential for improving relations with SMEs. The central policy-measure was the one that that prevailed[60] in the proposition 67, namely that of reassigning title to IP from research from the level of the individual researcher to the level of the academic institution.

The newly released OECD report on Turning Science into Business (see section 4) notes however that this question of formalizing title is not in itself sufficient to improve conditions for commercializing academic research: it may not even be necessary. It does however provide a set of benefits, including (i.) that it provides greater legal certainty for involved parties, (ii.) that it lowers transaction costs for partners/better bargaining position, and (iii.) that it fosters more formal and efficient channels for knowledge and technology transfer. These benefits may be useful in intensifying cooperation between university research and SMEs (OECD 2003).

However, this potential effect is neither automatic nor does it come without considerable pitfalls. The dangers recognized in the White Paper (and in the green-papers) revolve around what threat this change could pose to academic independence, or to what is termed 'free research' in the Norwegian documentation. A set of potential risks are warned against in the OECD report. These included the risk that commercialization efforts might limit access to publicly funded research results, might affect the cost and efficiency of research, might reorient research towards more lucrative fields, and might lead to conflicts of interests (OECD, 2003: 10). The report notes that several OECD countries have begun to feel a backlash against commercialization activity which underlines the call for safeguards against such risks.

[60] This occurred in substantial opposition to the majority position of the Bernt Green Paper.

This is a major challenge and it remains a major concern of many academic researchers in Norway. The implication is that the perception that this delicate balance is not being maintained would tend to undermine the legitimacy of commercialization efforts at the university among researchers and thereby counteract efforts to encourage the spread of entrepreneurialism among relevant populations of researchers.

Considering policy measures

In general, the aim of good SME-academic link policy is to improve the conditions for—and the quality of the way academic research is commercialized and the role SMEs have in that commercialization. The primary goal is an intensification of university-SME collaboration where this implies both a greater extent for cooperation (including investigating new areas of research and commercialization) but also an improvement of the quality of this cooperation.

This principle implies a set of things that public policy instruments can encourage and a set of things they can help discourage. In general, policy-initiatives should encourage the balanced build-up of research as well as entrepreneurship skills in both the SME and the university sector. They can also promote modes to identify/attract collaborators of two parties, and they can create incentives/pressures for university researchers to identify and collaborate with the main users of their research in equitable ways. The continual improvement of the U-SME link will depend on a set of more particular conditions such as the development of a diversified support structure for the commercialization of academic research, the availability of funding and advisory functions at different phases of the U-SME collaboration, the suitable build-up of activities/expertise within the research institutions themselves, and a significant degree of coordination between intra-mural and inter-mural transfer

activities (i.e. within university sector institutions and between them and support-structure initiatives).

These are areas where policy can have a role. An important aspect of its role is however to avoid attendant pitfalls, such as overselling the profit motives to academic researchers, imposing unrealistic time expectations for germinating U-SME collaborations, or promoting the growth of ineffectual bureaucracies. Such potential pitfalls entail sustained attention from the regulatory framework.

In general, the changing regime in Norway raises a set of new questions and challenges. These include:

- The need to develop the requisite human, institutional and regulatory resources for greater commercialization of academic research and better linkages with SMEs
- The importance that the changing technology transfer function involves the researchers as a partner not an opponent
- The question of the right to publish, and who has responsibility in cases where more than one researcher is involved.
- The need to develop strategies whereby the researcher is able/encouraged to participate in commercializing the invention.
- Methods to introduce the obligation to notify on researchers who are not principally aware of, nor sensitized to what is patentable
- Methods to deal with research results which might benefit by commercialization but which are not patentable
- The need to better understand the empirical effect of the changing regime.

Such issues need to be actively followed up. In this connection, several areas are set forth below which can help address policy concerns in the Norwegian case. These are structured with reference to four categories of recommendations the OECD recently elaborated on the strategic use of intellectual property by public research organizations. (OECD, 2003)

General

1. Make national policies on the U-SME relationship more coherent

The challenge in Norway is to implement the new legal conditions coherently across the university sector, other public research organizations, and the funding agencies. This entails ongoing attention to improve the complementarities in support-structure efforts, for example between programs in NFR, SND, SIVA, and the Norwegian Patent Office. Moreover, it entails a major competence-building exercise at several levels:

- To promote awareness and expertise about commercialization strategies in SMEs and in the university sector (not necessarily related to patenting alone)
- To promote participation among academicians that can shape the changing practice
- To encourage entrepreneurship among researchers and among SMEs
- To integrate a regime for intellectual property policies among the university sector, other public research organizations, and the funding agencies.
- And a general need to address the attitudes of both university professors but also SMEs to knowledge strategies that provide for the necessary balance between dissemination and control of new ideas.

A strategy one-sidedly extolling patenting is problematic here for several reasons. A more varied approach should be used which stresses different strategic channels and which concentrates on different contractual arrangements (with or without patenting). Here, concerns about how to safeguard public research missions must be followed up.

Government and Universities

2. Encourage development and implementation of policies at institutional level

A major challenge is to promote the further development of the support structure while linking it to formative efforts in university sector institutions. This requires coordination in the support structure while maintaining a degree of diversity among technology transfer activities. The challenge is to build up technology transfer

mechanisms within university sector institutions that will promote the dissemination of research results through commercialization, in line with the intention of the new law. In doing so there is a need to gear this new institutional set-up with existing technology-transfer activities, notably those built up under the FORNY program.

In general, this transition means that technology transfer activities which involve university sector research are being revamped. In this process, special attention should be paid not only to how to promote spin-off companies where this is called for. Also, attention should be directed towards how to partner with existing small and medium-sized enterprise not least in traditional sectors. Here, explicit links with the MOBI program should be considered.

A more general point during this process is that the design of the university technology transfer organizations should strive towards guidelines that are simple, flexible, but as uniform as possible from institution to institution. Flexibility is important in order to provide for the heterogeneous needs of technology-transfer in different disciplines. A common set of guidelines is important because it would benefit both potential commercial partners who would not need to learn different rules in order to partner with different university sector institutions, and it would promote a larger pool of technology transfer expertise at universities.

Special issues to consider in terms of common-guidelines include:

1. clear conflict of interest rules,
2. common contractual arrangements that address the question of when and under what conditions exclusive licenses are called for,
3. common contractual arrangements that include enforceable requirements to work clauses;
4. and common monitoring and enforcement provisions.

3. Enhance IP management capacity at public research organizations

There is a general need to increase IP management competences in Norway, among SMEs, among certain areas of the support structure, and among policymakers (Iversen, 2001). In light of current development, there is a need to raise sensitivity and increase knowledge and experience with the IP management issues in the university sector: IP management is becoming central to research management in the university sector. Increasing expertise does not mean simply increasing the number of patent applications. Patenting should not be treated simply as an alternative to publication or as success-criteria but should be based on an informed decision on how best to proceed with commercialization. One suggestion already under consideration is to introduce courses (or course material, even on an elective basis) in intellectual property rights into the curriculum (Iversen, 2001) of higher level courses in business-educations, (not least those oriented towards entrepreneurship) and potentially in science and technology studies. This would address the need for awareness and relevance both among tomorrow's professors and tomorrow's small business leaders.

4. Improve data collection and share good practices

There is a pronounced need for better monitoring practices of relevant activity including, the "need for timely and accurate information on the nature and extent of research collaboration between universities and industry, and on how it varies across discipline, type of university, sector, firm-ownership and time." (Calvert & Patel, 2002) The monitoring function is in fact formally called for by the change in laws concerning in Norway (e.g. on the effect of the change in laws). Areas to follow include, institutional strategies, collaborative research models, intellectual property rights, consulting activity, spin-off firms, and training and personnel links.

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Whitepaper: Ot.prp. nr. 40 (2001-2002) Om lov om endringer i lov 12. mai 1995 nr. 22 om universiteter og høgskoler og lov 2. juli 1999 nr. 64 om helsepersonell. http://www.dep.no/ufd/norsk/publ/otprp/045001-050002/index-dok000-b-n-a.html

Chapter 3: Country Report: Denmark

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Introduction: The new premises of science in society

It is generally agreed by both theoreticians, policymakers and practitioners that innovation increasingly happens as an interactive, dynamic and networked process involving multiple actors – with a focus on the interaction and collaboration between governance, industry and universities. The increasing interdependence among these three actor groups increasingly set new goals and standards that need to be internalized and worked with in order to secure sustainable economic growth.

Research collaboration is one of the more important existing initiatives for helping firms in general and SMEs in particular to absorb new knowledge and technology is one of the important areas when nurturing - although this ability does not automatically imply a strong relationship between industry and academe. A general European characteristic, especially conspicuous in Denmark, is the composition of industry. The majority of industry is to be characterized as small- and medium-sized enterprises (SMEs) – approximately 99.8 percent of the industry population has less than 250 employees[61].

The development and formation of the Danish research system falls neatly within the standard OECD or EU policy approach. Through the influence of national and regional policy initiatives as well as research counsels, science parks and technological service institutes the establishment and coordination of innovation-related processes are tried to be steered.

The prevalence of SMEs in Danish industry is highly prioritized and is mirrored in most of the activities affecting the research system. The existence of

[61] *Source:* OECD 2000

mediating institutions is a good example of improving the framework conditions for SMEs trying to benefit and capitalize from academic research.

The focus of the report will be on looking at the way in which SMEs interact with universities and public research organizations. The main issues addressed are:

- Academic-industrial linkages, especially with relevance to SMEs and the role of the policy and institutional support structures (including intellectual property rights)
- Institutional and cultural factors that affect commercialization of academic research and university-industry interaction.
- current state of academy-industry interaction in relation to the handling of IPR issues

The following chapters will go through the constitution of the Danish research system from the angle of the SME, specifically looking into

- Industrial structure (R&D, size etc.)
- Structure of public R&D (institutional framework, policy initiatives, current policies)

Policy events and debates relating to this group will be presented as to be able to establish a status quo picture of the conditions for collaborative efforts between public and private organizations - and from that to present initiatives to enhance the political, legislative and financial framework conditions for SMEs in the future. These points will be worked through in the concluding chapter.

Industry structure

As indicated in the introduction a specific feature of the Danish industry is related to composition. In the following chapter this characteristic will be pursued and related to parameters relevant for research and innovation, including patents, expenditure on innovation, financing, collaborative research etc.

Industry's role in innovation

The level of private sector research and development is often connected to the lack of Danish-based large multinational corporations. Yet other studies point to the fact, that

the size of Danish companies is not the cardinal problem, but is also under influence of factors as corporate form, branch and revenue[62].

In the paragraphs below some of the characteristics of the Danish industry and its role in innovative processes will be presented and elaborated on more thoroughly.

Composition

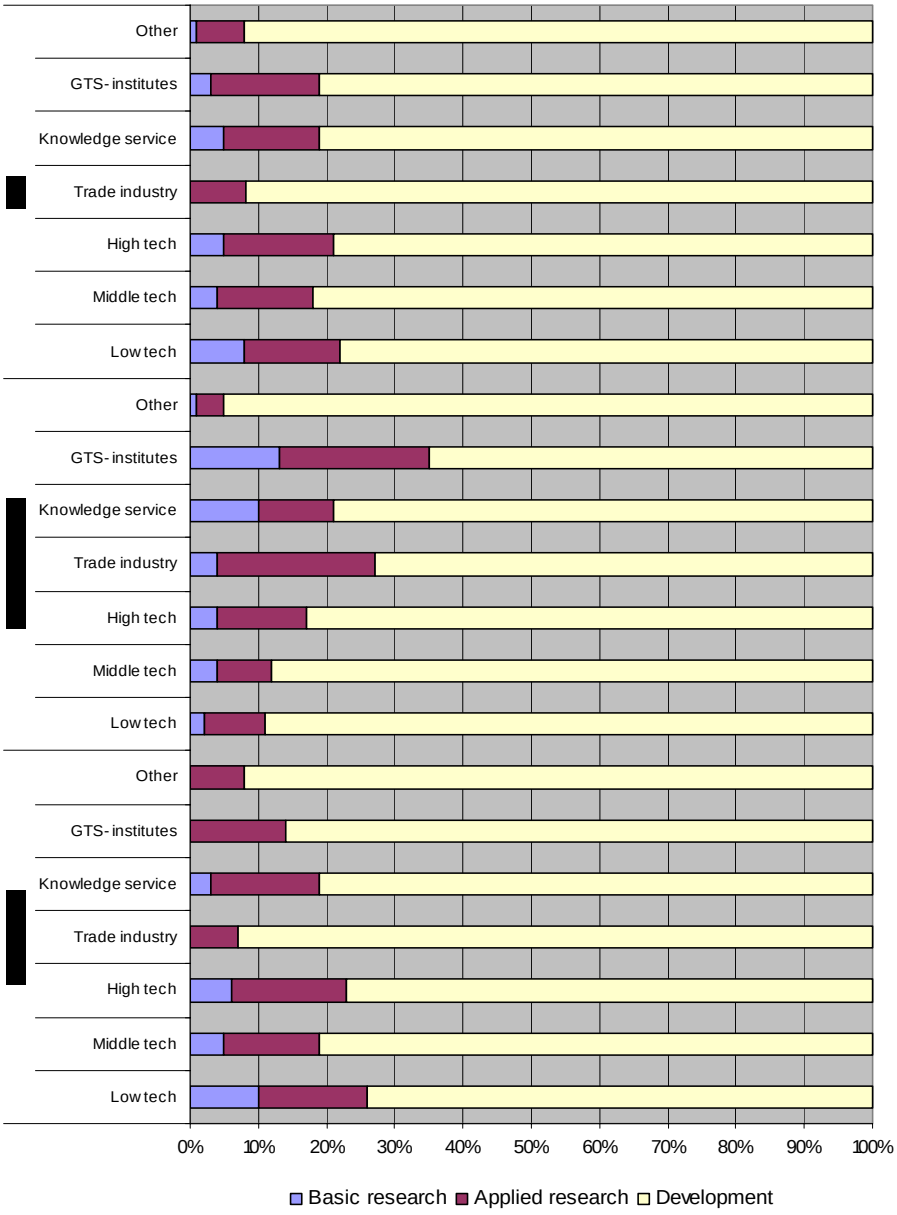
As indicated shortly above, the industrial composition in Denmark is characterized by a very large number of small and medium-sized companies and very few large industries. SMEs account for the bulk of Danish industrial firms, approximately 100% satisfying the OECD SME-criteria, having less than 250 employees. In OECD figures from 2000 the share of large firms +250 employees in the total amounted to 0.2%; very small firms (0-9 employees) represented 92% of the total (OECD 2000).

Research and Innovation

The companies in Denmark are distributed among very diverse sectors, and the number of research oriented companies in each sector varies a lot. In the context of composition, it seems quite indicative from multiple studies, that the extent of research and innovation is proportional to firm size. The larger the firm, the more likely it is to be an innovator. In relation to sector, there also exists remarkable variation in the distribution of innovators between each sector. Biotech and chemical industry as well as the electrical and optical manufacturing industry present the largest proportion of innovators within the EU (European Commission 2001).
The annual effort put into research by Danish companies divided in research type, sector and collaboration can be seen from figure 3.1.

[62] The Danish Institute for Studies in Research and Research Policy (AFSK 1998/6)

Figure 3.1 Danish sector classification and research types



Source: The Danish Institute for Studies in Research and Research Policy (AFSK 2002/5: table A.19)

The figure shows some interesting results, namely that:

- Collaborating research-based firms in the production industry use a larger part of their R&D budget on basic research than on applied research in contrast to non-collaborating firms.
- The opposite is true for all other sectors – applied research is prioritized here.
- Within knowledge-service and GTS-institutes a range of non-collaborating firms are conducting basic research.

Patents & expenditure on innovation

The composition of the industry also affects the amount of money used on innovation and closely related to this, the number of patents applied for. Statistics show that firm size also matter in this area. Cross-European studies show that only 15% of small firm innovators applied for a patent compared to 28% of medium-sized and 51% of large ones.

Considering the expenditures on innovation, they encompass a long range of different activities: knowledge creation through R&D processes of knowledge diffusion, absorption and appliance, investment in capital equipment etc. In this area large companies also dominate, spending almost twice as large a proportion of their turnover on such activities as do small ones (European Commission 2001). According to the expenses connected with a patent application many small firms rely on other appropriation methods such as secrecy and speed-to-market to stay competitive in the market.

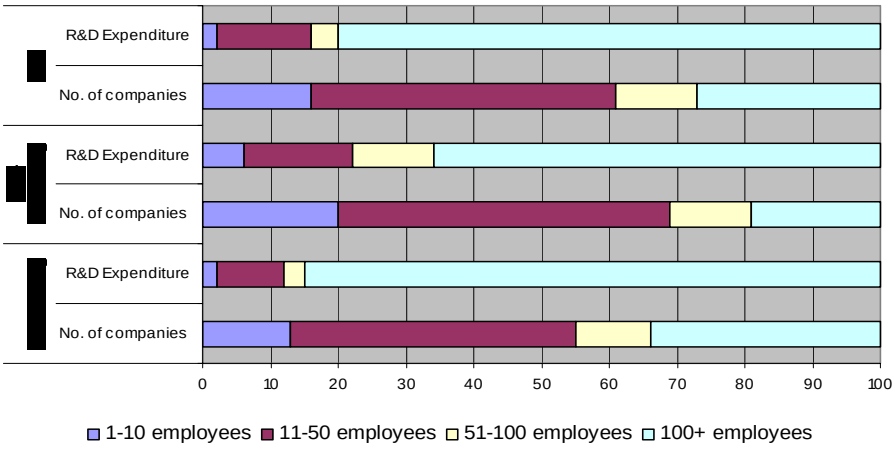
Research collaboration

Involvement in collaborative arrangements is part of the innovation possibilities at hand. Collaboration happens as partnership with enterprises within the same company group, upwards and downwards the value chain (suppliers and customers), universities or public research institutes. Symptomatic for Danish firms participation in collaborative arrangements is the fact the very few have established such an arrangement – yet the ones that have are very active in this area (Lundvall 1999). At the same time few of the arrangements are happening with public research organizations as the opposite partner.

The rate of collaboration among innovating firms increases with size. On aggregated level in Europe around 20% of small innovators have collaborative

arrangements, while approximately 50% of large ones in the manufacturing sectors, and around 35% in the service sectors do so (European Commission 2001). Figure 3.2 below shows the results when looking at Denmark. Firstly it is evident that there are quite a few research-based firms in firms with 11-50 employees. Secondly, that within the group of research-based firms there is a relatively larger share of large firms engaged in research collaboration opposed to those that are not collaborating.

Figure 3.2: Collaboration in Danish firms according to size



Source: The Danish Institute for Studies in Research and Research Policy (AFSK 2002/5: table A.8)

Thirdly, if we look at the total amount of money spend on R&D-activities the picture is in favour of the large companies. For collaborating firms 85% of total R&D cost is connected to firms with over 100 employees – and these firms only represent 34% of the total amount of firms. The middle-sized firms with 11-50 employees only constitute 10% of total R&D costs, yet represent 42% of the total amount of firms. Figure 3.3 shows Danish companies' choice of partner in research collaboration and shows a distinct difference, especially considering type.

Figure 3.3: Collaborating firms' size and choice of collaborative partner

Collaborative partners in									
Firms within same concern	Other firms	Universities	Research organization	1-10 employees	11-50 employees	51-100 employees	100+ employees	%	No.
				..: % :..					
x	x	x	x	3	31	4	62	100	116
x	x	x		9	8	8	75	100	18
x	x		x	0	9	5	86	100	31
x		x	x	0	0	0	100	100	3
x	x			2	52	14	32	100	108
x		x		7	44	0	49	100	24
x			x	17	0	16	67	100	19
x				14	34	12	40	100	106
	x	x	x	10	30	17	43	100	54
	x	x		9	53	18	20	100	50
	x		x	14	64	12	10	100	78
	x			24	47	13	16	100	348
		x	x	12	23	13	52	100	13
		x		23	36	16	25	100	37
			x	5	74	0	21	100	39
Sum of collaborating companies				13	42	11	34	100	1044

Source: The Danish Institute for Studies in Research and Research Policy (AFSK 2002/5: table A.7)

Large companies with 100+ employees are dominant when it comes to collaboration with sister companies and universities, while firms with 11-50 employees are dominant in collaboration involving universities and PROs. An interesting and positive tendency is the fact that SMEs come out as relatively active when their collaborative partners are universities or public research organizations. This tendency supports the findings by Lundvall mentioned above and as a whole supports policy initiatives and framework programmes for SMEs (Lundvall 1999).

Proximity and Regionalization

One of the most important characteristics of the knowledge society is the increasing existence of trans-disciplinary and boundary-spanning activities crossing national borders. Yet, an increased focus on regional development and innovation systems

reflects a (re) discovery by many academics of the importance of the regional level, and the importance of specific local and regional resources in stimulating the innovation capability and competitiveness of firms. Specific regional resources such as a stock of 'sticky' knowledge, learning ability, entrepreneurial attitudes etc. are seen to be of great importance in firms' efforts to be at a global competitive level. Building regional clusters is even perceived by some as the way to compete globally. Regional development has been taken up in most European countries and has been promoted by the European Commission as best practice solution for policy and business development in regions.

The regional cluster concept is one of the prevalent concepts within this tradition. Regional clusters refer to geographically bounded concentrations of interdependent firms (OECD 2001), and are connected to older concepts like industrial districts, specialised industrial agglomerations and local production systems. Within the regional approach social networks are often introduced to characterise the specific forms of governance based on social relations, trust and the sharing of complementary resources that typifies trans-disciplinary knowledge production today. Social relations are seen as the most important channels through which information flows, and geographical proximity facilitates the formation of trustful social networks.

In Denmark a focus on regional development is also prioritized. As described below the development of regional growth environments is one of the initiatives. Others include the establishment of regional network centres and policy institutions like the Greater Copenhagen Authority that functions as a unifying umbrella organization for a range of municipalities and administrative districts in the Greater Copenhagen area.

Financing and investment in R&D

Financial resources devoted to R&D are essential for growth and welfare in modern economics. Through investments in production and exploitation of new knowledge countries can reap the benefits from new innovative products and processes. In a sector perspective the share of funding in R&D by government, the business sector, other national sources and foreign sources is explored in figure 3.4.

Figure 3.4: R&D Financing by main sources of funds

	Business enterprise	Government	Other national sources	Abroad	Total
Belgium	66.2	23.2	3.3	7.3	100
Denmark	58.0	32.6	3.5	5.3	100
Germany (1)	66.9	30.7	0.4	2.1	100
Greece	24.2	48.7	2.5	24.7	100
Spain (2)	49.7	38.6	6.8	4.9	100
France	54.1	36.9	1.9	7.0	100
Ireland	64.1	21.8	1.6	12.4	100
Italy (3)	43.0	50.8	-	6.2	100
Netherlands	49.7	35.8	3.4	11.2	100
Austria	40.1	40.3	0.3	19.3	100
Portugal	21.3	69.7	3.7	5.3	100
Finland (2)	70.3	26.2	0.9	2.7	100
Sweden	67.8	24.5	4.2	3.5	100
UK (2)	49.3	28.9	5.5	16.3	100
EU-15 (4)	56.3	34.2	2.1	7.4	100
US (2) (5)	68.2	27.3	4.4	-	100
Japan (2)	72.4	19.6	7.6	0.4	100

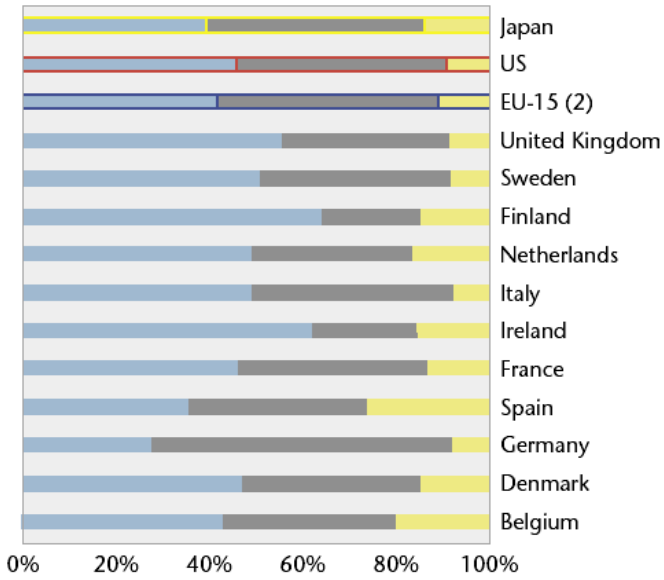
Source: EU Commission (2002) Science, Technology and Innovation – Key figures 2002

Denmark is not very different from the rest of European countries, yet in a Scandinavian perspective the level of business sector funding reveals evident differences. While Denmark is on the average of EU as a whole, both Sweden and Finland reveal business sector involvement on the same level as the US and Japan. Quite strikingly the foreign investment in these two countries is very low around 3%.

In the knowledge-based economy scientific and technological knowledge production and absorption is expected to be especially significant in high-tech industries, but will also become increasingly important for medium-tech and even

low-tech industries. Using this typology and taking a closer look on the business expenditure on R&D reveals figure 3.5.

Figure 3.5: Share of business R&D expenditure (BERD) by industry type



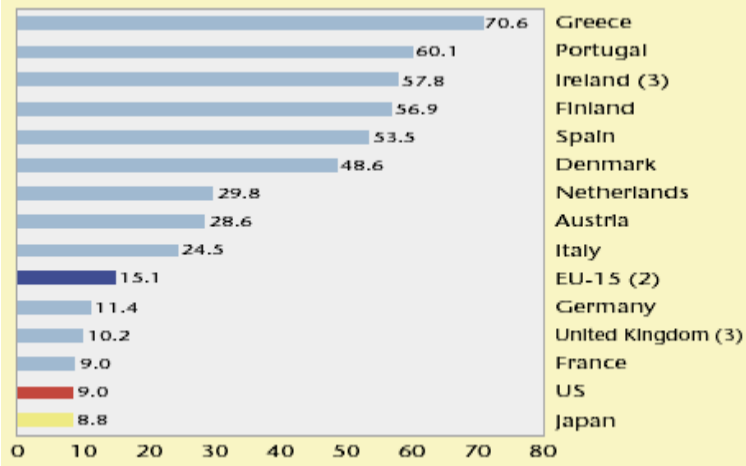
Source: EU Commission (2002) Science, Technology and Innovation – Key figures 2002

Compared to Sweden and Finland again, Denmark falls largely behind with approx. 47% investments in hi-tech industry compared to nearly 60% in Finland.

As indicated, SMEs are increasingly on the agenda according to both their innovative characteristics as well as their prominent existence in the statistics. In a finance perspective SMEs typically face difficulty in raising capital for R&D investments, lack of complementary assets or intellectual property protection to help them appropriate the benefits of their innovations, and difficulties in competing for government R&D funding (OECD 2000; European Commission 2001; European Commission 2002)

Public funding of R&D gives governments an instrument for directing resources to chosen research priorities as well as to certain types of firms. SMEs appear to provide a fertile breeding ground for new ideas and innovative ways of doing business. The SME share of publicly funded R&D sheds light on the relative importance of public support for SMEs' scientific and technological knowledge production and absorption. Figure 3.6 below shows that the share of SMEs in publicly funded R&D executed by the business sector is considerably higher in the EU (15.1%) than in the US and Japan (8.8%) which is supported by a well-known fact that SMEs are prevalent in European industrial structure. Within EU the figure further shows that small countries have a high share. Denmark falls within this group with a share of 48.6%.

Figure 3.6: Share of SMEs in publicly funded R&D executed by the business sector



Source: EU Commission (2002) Science, Technology and Innovation – Key figures 2002

Not only are SMEs capturing a larger share of government R&D funding, but also their potential for creating value has been recognised by the venture capital community. The majority of private venture funding in Denmark to date has flowed

to firms in the ICT and biotechnology sectors. Although venture capital does not aim at supporting R&D per se, its substantial emphasis on small, high technology businesses has enabled markets to become considerably more capable of sustaining large, risky investments in R&D in early business stages. The focus on early-stage idea generation and development is reflected in figure 3.7. Denmark shows impressive relative growth of 86.6% from 2000 to 2001 – especially considering seed and start-up capital[63].

Figure 3.7: Venture capital investment

Countries	Venture Capital Investment mio euro 2000				Relative change % 2000-2001			
	Seed	Start-up	Expansion	Total	Seed	Start-up	Expansion	Total
Belgium	80	185	261	526	-65.7	-61.3	-23.0	-42.9
Denmark	1	33	126	160	4 554.3	181.6	16.7	86.6
Germany (1)	392	1 261	2 143	3 795	-56.1	-22.1	-27.4	-28.6
Greece	–	9	110	120	–	232.7	-45.7	-23.5
Spain	3	197	569	769	61.4	-46.1	34.2	13.7
France	70	1 085	1 884	3 039	-57.2	-51.0	-61.8	-57.8
Irland	1	110	100	212	-26.4	-66.8	-13.9	-41.5
Italy	132	408	966	1 506	-83.7	-33.8	-22.9	-31.2
Netherlands	0	372	1045	1 418	174.6	-50.9	-28.7	-34.5
Austria	12	49	88	149	-34.4	-30.2	-2.9	-14.3
Portugal	–	31	104	135	–	-48.0	-45.1	-45.8
Finland	23	113	113	248	10.2	2.4	-35.8	-14.2
Sweden	28	199	334	562	-17.0	7.8	98.8	60.7
United Kingdom	64	1 548	4 487	6 099	94.3	-48.1	-61.3	-56.3
EU-15 (2)	807	5 598	12 330	18 735	-38.0	-37.7	-38.1	-37.9
US (3)	3 357[a]	28 019[b]	66 037	97 412	-72.5	-63.1	-61.1	-62.0
Japan (4)	:	5 096	1 224	6 321	:	0.7	-4.0	-0.2

Source: EU Commission (2002) Science, Technology and Innovation – Key figures 2002

As can be seen from the figure nearly all countries have been affected by the general downturn in the economy during 2000/01 showing an abrupt decline of venture capital financing in seed, start-up and expansion phased of new companies.

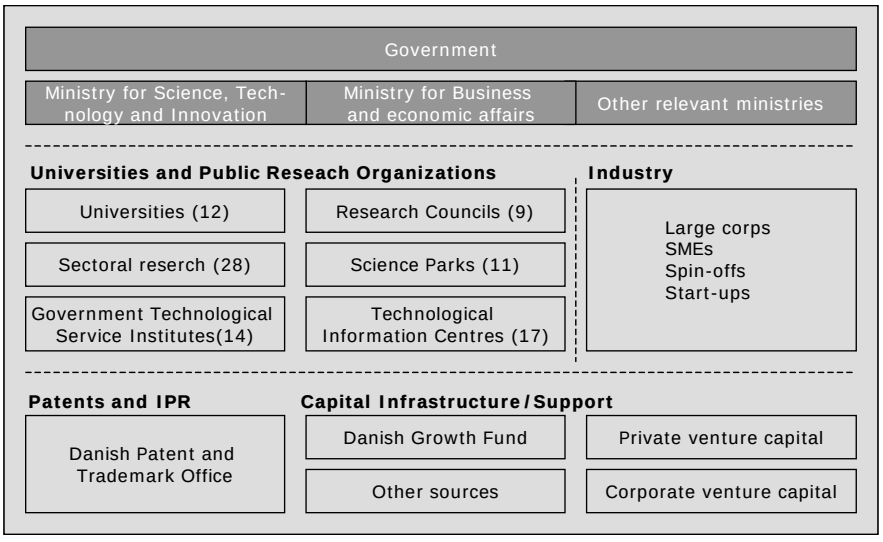
[63] The exorbitant change in venture capital investment in DK is partly a result of the fact that The Danish Growth Fund - a public business development organization – is now noted as a venture capital company. The Danish Growth Fund operates independently in the capital market, and facilitates the supply of venture capital in terms of start-up equity and high-risk loans.

Public R&D structure

In order to establish a common groundwork for the analysis the chapter below, sets out a simplified framework of the Danish research system. Constant dynamic and interaction of many different actors, whose behaviour and self-perception is under continuous change, adds even more to the blurring of the picture. In order to maintain the unit of analysis, the study will take its point of departure in explaining SME specific relations to the identified subsets in the research system.

Innovation actors and the current state of academe-industry relations

Figure 3.8 below depicts an overview of innovation related actors in the Danish context. The following paragraphs will be structured in two parts. First an introduction to the actor subsets, secondly followed by an analysis of the respective actor's involvement in the innovation processes on a national level.



The policy system

The policy system is more or less constituted by the Danish government, more specifically the Danish Ministry of Science, Technology and Innovation. As indicated

in the introduction, policy development is happening within the framework of a top-down process.

The Danish policy system has undergone some restructuring after the election of a Liberal-Conservative Government in the fall 2001. This change of Government has had implications for the number and composition of various ministries. Most important changes relevant for the development and deployment of innovation-related policies are:

- Change of the former IT and Research Ministry, now named Ministry of Science, Technology and Innovation.
- Ministry of Trade and Industry has been merged with the former Ministry of Economic affairs to The Danish Ministry of Economic and Business Affairs.
- universities have been placed with the Ministry of Science, Technology and Innovation previously a part of the competence of the Ministry of Education

Innovation policy developments

The reorganization and allocation of innovation related activities to the Ministry of Science, Technology and Innovation reflects a deliberate strategy in accordance with the growth strategy of the Government and its objective to make Denmark one of the strongest knowledge nations in the world. The object of the Ministry is to promote the interaction of trade and industry, centres of research and education and to strengthen coordination in pursuance of industry and science policy.

An explaining factor to this development is among others the emergence of the ‘systemic’ approach during the last years, as well the strong linkages between economic, industrial and science policies. An integrated handling of these three policy areas has proven to be essential for a coherent and integrated policy strategy in the longer run.

The merger between the former ministries of Business Affairs, Economic Affairs and parts of Housing and Urban Affairs affects the innovation system in a broader macro perspective. Main focus is monitoring the Danish economy and

preparation of the economic policy, legislation and surveillance of the financial sector, international economy and economic political cooperation within the EU. Additionally the Government has announced that during the autumn of 2002 a number of legislative initiatives will be taken with the aim to improving the efficiency of the Danish innovation system:

- simplifying the structure of the research advisory system,
- changing the owner- and governance structure of universities (University Reform)
- improving the transparency of the public research system

These initiatives must also be seen in context with the current general discussion of the 'Danish Innovation System' and the recommendations from the Danish Research Commission publicised in its report from November 2001[64].

At the time of writing the government has entered an historic agreement on university reform with the Social democratic party and the Christian People's Party. The agreement states that:

- In the future the university president is employed by the governing body, which is constituted by external professionals
- Head of Departments are employed by the management, whereas today they are democratically elected.
- Government is obliged to a thorough reorganization of rules and regulations in the university area.
- Each of the 12 universities has to have their board constituted before 1st of January 2005.
- Increased funding is directed to the universities. Reorganization reserves that earlier was taken from the universities, are being redirected.

The changes in the content of the portfolios of Ministry of Science, Technology and Innovation and Ministry of Economic and Business Affairs are mirrored in recent legislative changes May 29th (Act on Technology and Innovation, and Act on Business Promotion[65]). In addition the two Acts cancel out Act on Business Development, stipulated to come into force on January 1, 2002. The Act on Technology and Innovation establishes a Council for Technology and Innovation as

[64] Report from The Danish Research Commission, Ministry of Information Technology and Research 2001

[65] In Danish 'Lov om ophævelse af lov om erhvervsudvikling og om ændring af lov om erhvervsfremme', source: [http://www.retsinfo.dk/_GETDOCM_/ACCN/A20020042530-REGL]

an advisory board to the Minister. Furthermore the Act (together with Act on Business Promotion) creates a unified legislative framework for the policy areas that have been transferred from the former Ministry of Trade and Industry to Ministry of Science, Technology and Innovation.

The latest addition to the family of public initiatives is the establishment of regional growth environments. The government, in collaboration with the Ministry for Trade Economic and Business Affairs, has just granted DKK 50 million to the formation of these environments - DKK 16 million more than last year.
11 growth environments are planned, each focusing on specific areas of which can be mentioned fishing, music and robot technology. The environments are additionally secured co-financing from regional funds, amounting to DKK 35 millions[66]. Together with other regional initiatives all regions of Denmark are now covered.

A regional growth environment is founded on collaboration between industry, research and educational institutions, technological service providers (i.e. GTS) and other relevant actors and takes its point of departure on homogeneous industrial competences in a geographical area. The aim is:

- To establish knowledge and learning environments that supports the development and growth of the specific regional industrial competence.
- To make research and educational application oriented and targeted towards the regional industries needs for new products and processes.
- That research and educational institutions come to play a greater part in regional industrial development and that they obtain a proactive role in establishing collaboration.
- To develop and supply new and relevant further education relevant for the region
- That knowledge service providers develop – and adjust existing – services, knowledge etc. to the concrete knowledge and competence demands from the regional industry and institutions and through that to secure a reflexive anchorage and a more dynamic collaboration between the region and the knowledge service provider.
- That regional industry is supported in their development of processes, products, markets, human resources and organization.

[66] Source: Ministry of Science, Technology and Innovation, www.vtu.dk

Recent policy events/debates

In response to growing concerns about the state of the Danish research funding system and perceived lack of coherence in research policy, the former Government appointed a Research Commission to scrutinize the Danish Research system to assess the need for renewal and coherence. As a result of the change in government that occurred shortly after the commission presented its recommendations, it is now left with the present Government to continue the work of renewal of the Danish Research System.

In the recently published strategy plan 'Growth on Purpose' ('Vækst med vilje'[67]) the government sets the goal that Denmark should be among the best in the world to develop and apply new knowledge and technology. Analyses – for example 'Growth Conditions in Denmark' (Vækstvilkår I Danmark[68]) – show that Denmark, especially when it comes to applying new research results is lagging behind other comparable countries.

To address these issues the Government plans to present an IT and knowledge strategy in the beginning of 2003. A number of reforms will be carried out within the entire public R&D and innovation system. This includes as mentioned above the reform of the advisory system and management at universities. These reforms are intended to improve the transparency of and accessibility to the research and innovation system as well as improve co-operation between the institutions.

At the turn of the year 2002-2003 the Government will propose an action plan to further strengthen the co-operation between trade and business and knowledge institutions. The action plan will, based on an analysis of weak and strong competences in the Danish innovation system, point to action areas and propose new

[67] 'Vækst med vilje', published by the Ministry of Economic and Business affairs may 2002. [www.oem.dk/publikationer/html/vilje/vilje.pdf]

[68] ' Vækstvilkår i Danmark' published by the Ministry of Economic and Business affairs may 2002. [www.oem.dk/publikationer/html/vvilkaar/vilkaar.pdf]

initiatives. The action plan will be focusing especially on opportunities to establish mutual co-operation within knowledge institutions and companies as well as between them. The central issues will be the future interface between the technological service system, research parks, incubators, and the government research institutions and industry. Instruments to strengthen industry's access to knowledge and competence will be prioritised.

Concerning patents and IPR issues, the Government will initiate a reform of the present IPR system. How the administration of patents trademarks etc. can be improved and how the system can assist to an optimal diffusion and utilisation of new knowledge is the focus area. Subsequently, a plan for the future IPR system will be presented in the spring 2003. In addition the Government will work for the establishment of the European Patent. These reforms are dealt with more thoroughly later in this chapter.

Within the area of early-phase idea generation and entrepreneurship a framework aimed at strengthening entrepreneurship and increasing the number of entrepreneurs will be presented by government fall 2002/3. The ambition is that in 2010 Denmark be among the European elite as concerns entrepreneurs. The action plan will focus on the entrepreneur culture, access to start-up capital, as well as the regional advisory system for entrepreneurs. The Government furthermore intends to increase the number of start-ups based on existing knowledge in Danish research and knowledge institutions.

Universities and PROs role in innovation

Universities: Scientific research is a diverse activity, producing outputs with a range of social and economic benefits. Thus, universities and academe play a distinct and

central part in the innovation system and innovative processes. Strong indications of the expectations to the universities from the surrounding society are manifested throughout a wide spectrum, i.e. in policy initiatives and statements from industrial organisations. Universities have the role as primary knowledge producers in the knowledge society through the conduct of state of the art research and the education of high quality candidates.

Constituted by academic and national traditions the university seems to have entered the knowledge society with a certain entrepreneurial format. As research institutions the universities must be regarded as, indeed, very special institutions embedded with a certain characteristic that private research institutions cannot measure: the influx of students.

This special characteristic represents a key asset for the universities. First of all students are knowledge users, continuously in demand of knowledge during their education. At the same time the pool of students represent a potential group of future knowledge producers. Thus, the students are fuelling the further production of knowledge and it’s quite obvious that no organization - not even high growth businesses - can manage a flow-through of the same dimension.

Yet, still universities are in a transitional phase where former traditions and primary competence areas continuously slow down the organizational change needed to adjust to the new goals and expectations. In this sense, many departments and even whole universities have not yet begun building up the skills to participate as proactive partners in collaborative arrangements and trans-disciplinary and boundary spanning activities.

In a financial perspective the lack of speed in the organizational change process of the universities generate funding problems. The closer the research

objectives in the universities are to the commercial objectives of firms, on the one hand, or the policy objectives of Government departments and agencies, on the other, the more those commissioning the research should themselves have the incentive for funding an activity.

Summing up 3 key issues for the universities can be addressed:

- The market for science and research has become increasingly global in recent years. Danish universities have to compete with other European universities for talent and research contracts if their departments are to maintain or improve their world ranking. This means universities - particularly those which are recognised leaders in their fields – continuously need to be able to offer competitive salaries to potential staff, and having facilities and equipment conducive to top class research.

- Second, universities must be able to sustain and improve their current output. Under-investment in universities puts at risk the current high levels of research output, and there remains much to do to modernise university infrastructure. Furthermore, much research does not cover its costs let alone – which makes it even harder for universities to compete in the international labour market.

- Third, universities must have the resources and dynamism to move into new areas of scientific research and to ensure their work remains at the cutting edge. This means universities will have to be able to fund such investments but also to have the institutional flexibility to cross traditional disciplinary boundaries.

Feature: Aalborg University (AUC)
AUC is one of three universities covering western Denmark. AUC is situated in northern Jutland and has a strong competence within the technical sciences yet covers both human and social sciences as well. AUC already in 1996 formed 'Netværkscenteret' – a network institution focused on establishing university-industry collaboration

Data:

Turnover (1000 dkk)	10.945
Student intake	2531
VIP	1022
TAP	705
Ph.Ds	440
Publications	n.a
Patents (reg. inventions)	19 (22)

Public research organizations (PROs)

Apart from the universities in the role as primary knowledge producers other players have emerged in the institutional landscape by government initiative – as part of a national system of research counselling. These are represented by a range of formal public and semi-public institutions working as both knowledge producers and knowledge transmitters in society.

Within this group, the resources and efforts devoted to technology transfer varies widely between the organizations. Depending on their specific circumstances, and the balance struck in their missions between the needs of government authorities,

national industries and other stakeholders, their activities may be primarily in the area of basic or strategic research, or alternatively may focus on contract research and the development of applications.

The main objectives of the system are[69]:

- Counselling on all levels in Danish companies
- Independent of interest
- Secure and promote responsible resource utilization in the interest of society.
- Balance between research tradition and new thinking
- Coordinate counselling activities
- Represent both users and suppliers
- Contribute to an efficient utilization of research results for the benefit of society and business

The public research organizations can be separated in four subsets:

1. Government Research Institutions

Sector research covers a long range of different public research institutions, placed under different Danish ministries. The aim is to provide the ministry in question with research based counselling, and sector research constitutes about 20 percent of public research conducted in Denmark. The research focus is primarily problem oriented, with a clear purpose of application in society.

Feature: Risø National Laboratory Risø is a national laboratory under the Ministry of Science, Technology and Innovation. It carries out research in science and technology, providing Danish society new opportunities for technological development.	**Data**	
	Turnover (1000 DKK)	49.400
	Patens	18
	Publications	494
	Ph.Ds	60

2. Committees and Research councils

The primary tasks of research councils are to support fundamental research within different areas and to give advice on the role of research in the development of Danish society with a view to a better coordination and prioritizing of the overall resources available for research.

[69] Source: Danish Ministry of Research and Information Technology, www.fsk.dk - now the Danish Ministry of Science, Technology and Development (VTU)

Feature: Danish Social Science Research Council. The Council finds that a systematic and coordinated specialization and division of labour between the institutions and research environments in the social sciences is an essential tool in its efforts to promote research and ensure its high standard.	**Data:**	
	SSF, grants 2001 (DKK)	58.1 mio

3. Technological Service Institutes (GTS)

The GTS-institutes are functioning as self-governing institutions of public utility. No more than 13 different institutes are spread around the country, with each their own strategic and business focus. The GTS' are privately managed and management has the sole responsibility that the institute survives and develops in relation to its competences. The institutes sell counselling services on commercial terms to a broad range of Danish and foreign firms mostly SMEs. Revenue from these processes is used for consolidation, development of services and research and development.

The main focus of the GTS-institutions is to develop and transfer knowledge to different companies, and let this knowledge be internalized in these companies.

Feaure: Danish Technological Institute. DTI is DKs largest GTS with over 800 employees. DTI is established round a poly-technic approach covering R&D, counselling and educational activities in 10 main areas.	**Data**	
	Turnover (1000DKK)	1.600
	R&D projects (DK & Intl.)	136.000
	Spin offs	11
	Patents	4
	Publications	165

4. Science parks / innovative environments

The primary goal of the science parks is to promote and enhance the establishment of new companies through the use of knowledge from a range of research institutions connected to the science park. Science parks are settled in specific, limited geographic areas and are mostly connected to one or more universities. Via this connection the parks work to create the best possible framework to support the development of innovative and research-based business enterprises.

Feature: CAT Science park CAT is a competent and venturous partner when it comes to translating high-tech research into financially viable business ventures.	**Data:**	
	Established firms ('98-'02)	39
	After investment in 10 of these firms	200 mio
	CAT rated 3 out of top 5 seed investments in DK in 2001	

5. Technology Information Centre (TIC)

Technological Information Centre - TIC is a nation-wide, independent, non-profit organisation with at least one regional centre in each County. TIC offers expertise and consultancy on possibilities and tools for development and growth in SMEs and acts as a contact to relevant experts and knowledge centres. As an independent and non-profit organisation the objective of TIC is solely to create positive results and development for the companies involved.

Feature: Technology Information Centres. TIC is now a fully established initiative with 17 centres coordinated centrally through TIC Denmark. The centres employ approx. 125 people, of which 85 are counsellors, offering their free services to SMEs.	**Data (2001):**

Individual business contacts	15.005
Collective business contacts	8.885
Satisfaction with contact	93%

As can be seen from the bullets above most of the public research institutions are directly or indirectly involved in providing services relating to SMEs or facilitating business start ups. And in a historic review the importance of PROs in Denmark is not to be underestimated.

Throughout their 20 years of existence, PROs have grown to become important knowledge brokers in the research system - evolving from pure government financed organizations servicing the government to function on market-like terms with a strong position in the frontier land between academe, governance and industry. Yet, continuous changes in the research system put forth the question whether the market for research and knowledge service will keep on existing in the same scale as earlier. Answering the question is not only decisive for the development of Danish research and knowledge service but of course for the growth and welfare in the country.

From a public perspective securing the best possible knowledge service and counselling is important. And within that picture the PROs need to establish themselves if they are to secure there role as important partners in the research system. Yet, specific developments outside the reach of the public research organizations are hampering their position:

- As indicated in 3.4.1 the change of competence in universities and the industrial composition evidently influence the market for knowledge service. Universities are increasingly participating in research collaboration with industry, as well as a growing part of industry has developed the competences to benefit from direct partnerships with universities. This development will continue to accelerate and crowd out the need for knowledge service and counselling in these companies.

- Pari passu with this development, a long range of companies either have no reasons for establishing research collaboration or simply haven't got the resources for it – and these companies are to a little extent customers for traditional knowledge services.

- From a policy point of view, it's a wish that the universities gain the competences to deliver the research- and knowledge service demanded by Danish companies.

- A number of large research based companies have highly qualified knowledge environments suitable for solving research- and knowledge service tasks for the public and the private sector and this "outsourcing" is a rationalizing the way that companies get hold on valuable knowledge as well as creating important synergies.

- Knowledge sharing increasingly happens through informal, flexible and dynamic networks etc.

All in all, these tendencies are problematizing the role of PROs in the Danish research system. At the same time some of the organizations are competing with universities for public funding, as well as internal competition between the different types of PROs is hampering the development of market-driven private knowledge services. Competing with counselling firms on pure market terms raises another question on efficiency. Is it possible for the PROs to redefine their core business and, instead of working with knowledge- and technology development, to deliver well-defined concepts and solutions to customers who haven't got the technical insight? There are no reasons why PROs cannot become central knowledge producers in the innovation system – yet it demands that they redefine and develop themselves to meet the demands of the surrounding world. These demands have certainly been realized by all types of PROs, each formulating their own strategy for the future competition in the

market for knowledge production and brokerage. As entities in the same field all types of PROs face some of the same problems, thus their strategy formulation shares some similarities[70].

The patent system and its role in innovation

With the rapid emergence and deployment of new technologies, IPR mechanisms – hereunder patents – are becoming essential to protect inventions against infringement and to stay competitive in a market where knowledge increasingly is the competitive advantage.

As indicated in previous paragraphs this holds true for all the actor groups in the innovation system, from universities over PROs to the industrial sphere. Yet as noted in section 2.1 patenting is not the only appropriation method available but surely the most expensive.

In a SME perspective the concern in Denmark is an under-use of patents and intellectual property rights (IPR), therefore relying much more on secrecy, speed to market and lead-time than on the protection offered through an IPR-system. In these cases firms base their appropriation decision on pure short run revenue terms. If the revenue brought home from the market via a speed-to-market decision exceeds the revenue via a patent in the short run – then there's a large probability that taking a patent is not the strategy chosen.

Both nationally and internationally activities aimed at promoting and disseminating information on the use of IPRs are taking place. Thus, National patent

[70] A range of evaluation reports on the different types of PROs exist, elucidating the need for restructuring and new strategies. See for example:
Strategi for Teknologisk Service 2002-2005, Ministry of Science, Technology and Innovation 2002
Gennemgang af sektorforskningen, The Danish Research Council, 2002
Evaluering af forskerparker, Ministry of Science, Technology and Innovation 2000

offices are changing their roles as merely being repositories of information to actively promote the use of patents and IPRs as a tool for continuous competitiveness. Analyses from the European Patent Organisation (EPO) as well as the EU Commission (European Commission 2001)show that the low patent activity among European firms is due to the large financial and administrative costs of taking out patents, as well as doubts as to whether the firm can overcome the financial burden which follows from possible litigation involving patent infringement (EPO 1999, 2000). Corresponding studies (The Danish Institute for Studies in Research and Research Policy 2002) suggest that this is a problem for SMEs. In addition, the study of the period of 1990 to 1995 shows that large firms patent 30 percent more inventions per employee than small and medium-sized firms (The Danish Institute for Studies in Research and Research Policy 2000).

In order to encourage the Danish SMEs to make use of the intellectual property system, the Danish Patent and Trademark Office (DKPTO) has embarked on a two-track approach. The first approach is to take domestic measures focused on supporting SMEs to overcome the challenges related to effective use of IP system (intellectual property system). The second approach is to initiate, through the government, within the framework of the European Commission and the European Patent Organisation, measures on the European level aimed at encouraging SMEs to use the IP system.

In 1999, the DKPTO published a discussion paper entitled "Industry Policy in Denmark," which was initiated by the Ministry of Trade and Industry. It reviewed Denmark’s IPR regime and made proposals on what should be done in Denmark and in Europe in order to strengthen the IPR system and at the same time encourage

enterprises, in general, and SMEs, in particular, to make use of the intellectual property (IP) system. Below is listed some of the specific DKPTO initiatives:

- The Danish Government has initiated a two-year project with the objective of strengthening the Danish IPR culture. The expected result of the project is having enterprises armed with more effective IP management tools, which will enhance companies' competitiveness.
- The DKPTO gives special attention to its activities aimed at supporting Danish SMEs to protect and exploit their intellectual property. The DKPTO has established a call centre with the objective of handling intellectual property related inquiries of SMEs. The centre provides thorough guidance on intellectual property matters and on commercial services of DKPTO. It is estimated that the centre handles about 150 telephone inquiries daily.
- The DKPTO also provide library services. Main users of the library are SMEs. Users can access, free of charge, Danish and foreign patent information. In addition, users can access information on utility models, trademarks and industrial designs.
- The DKPTO has launched, a communication concept – profitgate- with the aim of disseminating strategic IP knowledge to SMEs. The concept consists of a web site www.profitgate.dk (in Danish), a red direct line within the DKPTO to which potential user can call to have more information, IP articles to the media, rounds of presentations in co-operation with the business sector in Denmark etc.
- On an annual basis, the DKPTO provides 30-40 awareness-building courses. Participants to such courses include SMEs representatives.

Pari passu with these initiatives a range of national and international initiatives with relation to the Danish patent system are worked with on policy level. Most important to mention are[71]:

International initiatives:

- Efforts are stepped up to produce an EU patent but in spite of widespread political awareness - and a major Danish contribution - the patent failed to become a reality during the year.
- The World Intellectual Property Organisation (WIPO) opens a debate on the future of the patent system. The Danish Patent and Trademark Office (DKPTO) formulates Denmark's contribution after consulting Danish business, the intellectual property sector and other interested parties.
- The task of setting up a European insurance scheme to protect against infringement of patent rights proceeds slowly but surely. Two proposed schemes - from the EU Commission and from Denmark - are expected to be unveiled at a conference in Copenhagen in 2002.
- Denmark continues to attract understanding for its view that the future European patent system has to be based on stronger European patent collaboration within EPO (European Patent Organisation) and on national patent authorities' expertise and bearing upon innovation in their respective countries.

[71] *Source:* DKPTO, annual report 2001

Principles for policy making – examples and perspectives

Having now presented the actors in the research system and the current state of academe-industry relations and relevant case studies it is time to focus on a coupling of the important perspectives and actions points between those two parts. This is done in order to be able to establish a solid foundation for further development of the research system and improvement of SMEs participation in research collaboration.
At this time it's highly important to evaluate current policy efforts in relation to industrial composition. Among some of the questions that will be answered in the following are: What are the characteristics of Danish research policy – and what on what foundation does policy development happen? Which perspectives are raised in relation to SMEs and what events, initiatives and conditions have relevant influence on SMEs? These are some of the most conspicuous questions that need attention.
In the following, a range of overall areas is presented, each of them building a bridge between functional trends in the research system and practical perspectives raised by practitioners in the case studies.

Policy development and SMEs

Taking the point of departure in chapter 3.2.1 and 3.2.2 it's clear that a broad array of policy initiatives to enhance research collaboration, simplify laws and regulation and streamline the innovation process are already functional - and others pending to be put to work.

During the last 10-12 years actors in the research system have increasingly met a demand from political hand to stake on hi-tech sectors – specifically universities have been urged to focus on the education of candidates within the natural sciences, computing etc. From this increased focus a hi-tech policy paradigm or discourse has emerged. The discourse has tended to overlook and disfavour other

scientific fields and has been rather one-sided in its focus - as a natural consequence overlooking the needs of firms within these areas.

An ongoing debate concerning the consequences of the one-sided discourse has taken place during the last 1-2 years, fostered by reports by Danish Commerce & Services, Danish Industry and Greater Copenhagen Authority etc[72]. The theme of the discussion concerns the identification of high growth industries, labour market demands, and which business sectors that will secure continuous growth and welfare in the future.

The shift towards a more networked economy has been accompanied by – and facilitated – a tighter integration of the knowledge economy and an expansion of market and non-market knowledge transactions. The production and application of scientific and technological knowledge has become a more collective effort, linking the activities of industry, academia, and government. Formal and informal co-operation among institutions has become crucial for reaping the full benefits of knowledge creation and fostering the development of new technological innovations. Virtually all forms of collaboration, including co-operative research, public/private partnerships, international and domestic strategic alliances, and foreign direct investment, show signs of increasing.

In this context the handling of an increased stream of information and knowledge has opened a huge demand for knowledge services by which the knowledge service industry has become the fastest growing area at the moment. This development of course clashes with the congenial attitude in society that the important growth industries are found in hi-tech sectors such as biotech, nano-technology, pharmaceuticals etc. From a policy maker perspective the knowledge

[72] 'Vejen til vækst', Danish Commerce & Services 2002. Rapport xx, Danish Industry, Rapport xx, Greater Copenhagen Authority

about the framework conditions of knowledge service firms i.e. advertising agencies and organizational development firms is limited, while other sectors are much better covered due to statistical coverage and a prominent part in policy development already. Re-saddling in policy development does not come easy.

When evaluating the current stream of policy initiatives it becomes apparent that the formation of innovation related policies in Denmark happens as a top down approach based on the common principle to, as widely as possible, incorporate and affect industry and university circles. Supposedly conditional on historic and cultural principles, it's not Danish standard to differentiate policy initiatives. The same historic and cultural factors manifest themselves in the replacement and dissolution of policy initiatives. Some examples exist on initiatives that, quite contradictory to their performance, have outlived its usefulness - a situation that adds to the blur of ongoing activities and actors governing the research system.

A number of good examples exist, where the role of institutional setups and initiatives in the innovation system has petered out. Through the last two decades the GTS network with success has offered their services specifically to SMEs. Yet, the GTS institutions increasingly have experienced a declining market for knowledge services mostly because the financial demands to the SMEs going into collaborative arrangements are too high. At the same time a declining share of government funding is forcing PROs to seek new sources of support.

The centre contract scheme[73], has tried to leverage this situation but still there's no evidence that it has helped in overcoming the problem – the in-built demand of 25% financing coverage by the SME in the centre contracts is not

[73] A Centre Contract is a juridical binding agreement between firms, technological service institutes and research institutions on the accomplishment of a development project. The firms fund their own expenses, while The Danish Agency for Trade and Industry and The Danish Research Councils have the possibility to co-fund the technological service institutes and the research institutions.

unproblematic. The co-existing ‘free of charge’ program TIC is established to enhance the possibilities of SMEs and their decision-making without demands to funding. TIC is a nation-wide network of Technological Information Centres that provide assistance to the business community and especially SMEs. These services comprise information, advice and assistance in finding relevant counselling for firms; they also collaborate in campaigns and programmes initiated by the government with all services provided for free.

As mentioned earlier, intellectual property is a key policy issue in the Danish context. Patents are increasingly asserted as the gold standard for competitive advantage in organizations. Yet a range of softer appropriation methods are at hand, especially used by SMEs facing the immense cost of taking out a patent. Secrecy and speed-to-market are the most used methods when organizations bypass a patent application. European studies show, among other things, that patents are a relatively unimportant source of information compared to other methods of learning about technological development (Arundel & Steinmüller 1998). In a collaborative perspective this subject also touches upon ownership rights to results and the possibilities of a common patent.

In addition to different ways of protecting ones IP rights and there are also sectoral and industrial differences in the use of appropriation (Arundel & Steinmüller 1998). Yet, the material put forward in this study is not in any way substantial for concluding how systematic these tendencies are, i.e. concluding on which industrial sectors that patent and which does not. Surprisingly CASE 3 showed heavy patenting activity throughout a 10 year period in a low-tech area. Still, collecting the results from numerable studies indicate that patenting is mostly connected with high-tech industries (Arundel & Steinmüller 1998).

Among specific SME initiatives taken in recent years the following should be mentioned:

- Establishment of business incubators. The incubators are among the most risk-taking sources of finance in the Danish financial system. The incubators function as the first link in an intertwined system of financial institutions such as the Danish Growth Fund, venture capital investors, Business angels, and institutional investors[74].
- Establishment of 11 new regional growth environments. Together with other regional initiatives all regions of Denmark are now covered – both securing diversification and covering such diverse industries as fish, music, robots, plastic etc.
- Improvement of capital structures for SMEs through loan guarantee schemes, tax changes etc.
- Better and cost-saving patent services directed towards SME

Universities and SMEs

Following the line from the previous section, the state of university research, collaborative capabilities in universities, funding and ownership issues are also decisive for the extent of research collaboration and knowledge dissemination to SMEs. In relation hereto questions as: who owns inventions developed in the universities and how is this handled in collaborative arrangements? Is it possible for universities to act as professional entities in the market - and how do they handle the possibility of receiving revenue on these inventions? What areas of research are likely to serve human wealth and welfare in the long term?

As indicated earlier, a range of policies to enable universities – and to a lesser extent other PROs – to respond to increasing pressures while maintaining their ability to conduct basic research has been issued. Many of these responses relate to changing mechanisms for setting research priorities and for funding, as well as for development of human resources. To a large extent, these changes are taking place within existing

[74] During the period 1998 to 1999, the incubators have contributed to the establishment of 172 innovative companies founded on new, knowledge based project ideas. Approximately 100 of these project ideas are patented. The projects are the result of a large number of requests from potential entrepreneurs, researchers, students and others who are interested in establishing their own businesses. The incubators have registered a total of 2.631 requests, which have resulted in the initiation of 549 feasibility studies and of 176 pre-seed capital projects during the first two years of the initiative.

government structures for managing and funding the science system. These structures paradoxical constrain the types of reform possible.

Considering ownership the removal of the 'teacher exemption clause'[75] in 2000 marked a distinctive movement giving universities a head start in capitalizing on inventions made by researchers employed at the university and at the same time making it possible for universities to generate profit from the appropriation of these inventions. Only few of the Danish universities have yet begun to handle their intellectual property and appropriate inventions – but the ones who have (i.e. Danish Technological University, Aalborg University Centre) have established solid partnerships with industry and account for a relatively large number of patents and spin-offs from their activities. This shift is urged by policy makers and the university reform is supposed to push the transition towards a more professional handling of research collaboration, partnerships etc.

Whether this transition is all in favour of SMEs or whether it affects bigger business entities to a larger extent is not to be derived directly – but there are reasons to believe that universities qua their more professional handling of their surrounding world will be able to attract more SMEs to joint activities.

Among specific university initiatives taken in recent years the following should be mentioned:

- Removal of the teacher exemption clause. Enhancing the way universities handle inventions made within the institutions and highlighting the demand from society that universities have to focus on capitalization on research.
- The new university reform, partially building a formal bridge to the surrounding world. Professionalizing the leadership of Danish universities through the use of professional boards of directors, appointing a professional principal.

[75] 'Lov om opfindelser ved offentlige forskningsinstitutioner', Law nr. 347 from 2nd of June 1999

Conclusion

As could be read from previous chapter a number of SME related initiatives exist, but the general principle in policy development is a top-down approach incorporating perspectives influencing as wide as possible. Through an increased interaction between academics and government policy makers have been active in learning the coupling of innovation policy developments in economic theory. A range of policy initiatives are inspired by research in innovation. In particular, advances in the system approach to innovation and the evolutionary theory has contributed to a change in the way innovation policy is argued. Some of the policy initiatives and some of the overall formulations of government policies may be characterised as a systems approach. Moreover, the vocabulary is close to what is used in the literature on systems approach to innovation policy.

Yet, practical policy development is happening on a relatively unplanned basis rather than integrated in an overall strategy. In relation hereto and to the paragraphs above it is reasonable to assert that policymakers need to focus on differentiation when it comes to policy development. Evidently there's a large diversity both within industry as a whole, yet also within the SME group. Huge differences between the need of i.e. hi-tech and ´bread and butter´ SMEs exist. Recognizing the large amount of SMEs in the economy, government need to provide a favourable environment for this segment of the business community and reflect the role that SMEs and entrepreneurship play in achieving economic and societal goals in government policies.

Challenges for policy development

Throughout this report is has been mentioned that the increased complexity of innovation probably is one of the most important changes in the way the innovation

process is perceived. The increased complexity has a number of implications. To an increasing extent it has been recognised that new forms of organisations, augmented services in relation to manufacturing, and development of new after-innovation methods are crucial for economic performance.

In that sense, the way policy makers think about innovation is gradually broadening from a focus upon industry towards innovation in services as well. Improving the prospects for economic growth will require complementary actions by many stakeholders in both the private and the public sectors (e.g. industry, academia, unions and governments). This section will focus on the actions that government can be taking in the future development of a coherent and effective innovation policy. Identified below are three possible policy sections in which some of the future challenges for policy development are positioned:

Policy section 1: Innovation and entrepreneurship

Extension of public-private collaboration and partnerships
Within most industrial areas, whether hi-, middle or low-tech there's a constant need to renew products and processes to meet the demands of increased international competition. Extensive public-private collaboration, knowledge transfer from academe to industry etc. will help to position Danish industry on a global market. At the same time efficiency criteria needs to be implemented in order to streamline the tasks undertaken in public institutions.

Increase the quality of public business development/promotion/knowledge service and specialization of knowledge service
As argued in chapter 4.1 there's need for scrutinizing the governmental innovation initiatives. The future research- and knowledge service system have to build on specialization and division of tasks in order to be economically efficient and competitive. Not all of the institutions have succeeded transforming their activities and services according to the development in industry and the research system as a whole. This impedes the quality of the services offered as well as there an overlap between the services offered by different actors. As it is now knowledge and services targeted SMEs is spread out in many different institutions only helping to blur the competences of the organisations and the tasks carried out by these. To intensify and facilitate easy access to these resources well-defined competence centres needs to be established – building on synergies between different actors.

Better coupling between universities, science parks and business incubators.
In order to strengthen the knowledge environment synergies between these institutions needs to be explored. This entails both increased collaboration in research, development of cross institutional educational initiatives, internships etc. Furthermore geographical proximity needs to be considered as a very relevant factor for the different innovation efforts. Proximity and regional affiliation is a major issue when pursuing research collaboration with industry, PROs and universities.

Networks and relations
Innovation increasingly happens in trans-disciplinary setups with multiple people involved. The dynamics of networks are an explaining factor for the outcome of collective inventions. The networks are driven by the exchange and circulation of knowledge and information between socially connected individuals and this is the key factor to the innovative performance. In view of the growing evidence of their positive effects, collaborative and partnership approaches, networks and clusters need to be actively promoted by government to help alleviate the disadvantages of small firms with respect to resources and location.

Policy section 2: Capital and funding

Enhance framework conditions for early-stage venture capital investments
Venture capitalists involved in early-stage development are dependent on R&D, educational activities spin-off investment opportunities. At the same time attracting more funding to the early stages is essential to support early-phase idea generation as well as enhancing the possibilities for the high risk/high profit situations often connected to early stage investment Access to capital is crucial in a development or growth phase – yet it's difficult to get. Especially in U-I related research projects the goals and expectations to time frame, revenue etc. to most capital resources are not consistent with the time horizon and practical execution of the research project. SMEs experience considerable difficulty in obtaining financing during the start-up stage, and in many cases they need to look to alternative financing sources, such as credit unions, leasing companies, personal and family relations.

Coherence between capital accessibility and the industrial action points
Increased and efficient sector-specific innovation support through financing can only happen if there's willingness among investors to invest in certain sectors. Both the traditional financial system as well as VCs needs to support SMEs need for developing new ideas and services. This could be alleviated through the use of pension fund resources for investment in unoted papers, with special emphasis on innovative, knowledge-based growth firms.

Policy section 3: Universities and education

Industrial engagement in higher education
One of the results of universities adopting competences from the world of industry is that U-I relations are dealt with professionally and on a more frequent basis. Industry is more and more brought to play through the use of advisory boards, participation in lectures, internships etc. In the future development of the education system, and the further steps to operationalize theoretical knowledge and bring it to use in practical, real life situations the relationship and involvement of industry is extremely important. The educations offered today are in some instances out of step with the actual needs for innovative, entrepreneurial and networked candidates. The educational system still focuses on the competencies needed in the industrial society Providing with the educations that matches the competences needed in the knowledge society will be a must to secure further development of important growth sectors.

Larger supply of research based supplementary education on all levels
When learning and unlearning has become the single-most important factor for individuals and organisations continuous training and education is needed. Public research institutions need to offer business spheres with up-to-date information on leadership and serve as inspirational source in the business community. It's important for society that well-educated employees continuously have access to further education.

Increased management competences in universities and PROs
The competences of universities are in a gradual transition towards an implementation of industry-like

competences. This movement is supported by a general expectation in society for society to perform and deliver applicable research that can be used to secure the growth and welfare of society. Not all universities have yet begun this organizational transformation which hampers their handling of collaborative efforts with industry (negotiating contracts, time perspectives, ownership of results etc.)
The transformation needs to be steered by strong management decisions as well as competent management is a prerequisite for the future university

Larger and stronger research units (cross national, institutional, networks of excellence etc.)

The proliferation of research networks, teamwork, global electronic communication and other collaborative forces are the 'raison d'être' for the increasing accumulation of knowledge and technique. Thus, the notion of scientific researchers working alone is obsolete in contemporary science. The progression towards more complex scientific problems implies that individuals working independently cannot solve these problems.

Key challenges

The above-mentioned policy sections represent a broad array of areas and focus points for future policy developments. Although choosing key variables from these propositions implies the problem of simplification the identification of the following 3 key challenges provides more action-oriented recommendations.

1. Creating an innovative and entrepreneurial culture - the role of education and training

In many ways fostering entrepreneurial attitudes particularly starts with education. A variety of reports show encouraging signs within this field – both within existing educational schemes and training programmes for professionals[76]. Still the supply of entrepreneurship-based education is limited to not more than a few courses in higher education, partly focused in the technical, natural and social sciences

In order to arouse an interest for becoming an entrepreneur at an early age teaching activities in primary school needs to be put on the agenda. Development of a framework for increased cross-school collaboration within this area, creation of educational material involving local SME industries and web-based support could be

[76] Global Entrepreneurship Monitor 2002. [http://www.gemconsortium.org,], 'Vækst med vilje', published by the Ministry of Economic and Business affairs may 2002. [www.oem.dk/publikationer/html/vilje/vilje.pdf]

seen as tools. Adjusting the traineeship period in $9^{th}/10^{th}$ grade to focus on innovative activities and entrepreneurship supplemented with course and feature weeks could create a solid understanding for innovative processes, product development and the entrepreneur.

These features should then be supported through further activities within this field in gymnasiums, schools for apprentices etc. Entrepreneurial thematics will then be a consecutive focus area throughout the educational period of young people helping them to gain insight into innovative processes and entrepreneurship.

2. Re-conceptualizing/-combining public knowledge services and business promotion

As indicated in preceding chapters the industrial composition as well as political will during the last 2 to 3 decades has facilitated the growth of a public support system within innovation and knowledge related services - in order to secure a fruitful transfer of knowledge from public research organizations to the Danish industry – specifically to SMEs and entrepreneurs.

Having existed now for 3 decades and undergone many changes a concrete scrutinization of the system is needed. As indicated the system is constituted by an array of services from TIC, GTS over science parks to regional growth centres – with smaller groupings in between. All these add to a blurring of the picture of where to go for specific services. At the same time these organizations undertake overlapping tasks leading to lack of specialization. To overcome this blurring it may be necessary to promote a greater centralisation of the support competencies than we see today. Regional growth centres can then facilitate knowledge services in local areas – in combination leading to a higher quality of knowledge services and to a united access in local areas.

Mechanisms which can strengthen the supply and quality of public based knowledge services to entrepreneurs and small enterprises need to be introduced. One way in which this could be done is to encourage the development of a private based counselling network of practitioners, business angels, banks, lawyers, etc. could supply with easy-to-use knowledge services especially in early phases. In combination the two propositions would create a better division of services and give private based services a higher degree of responsibility for servicing the entrepreneurs and small enterprises. It should be borne in mind however that SMEs do not all presently possess the competence to be efficient procurers of these types of services.

3. Creating a vibrant market for innovation funding – closing the funding gap in the early phases

There are, as noted, two specific ways to gain capital investments – either through public or private channels. The present situation is that there is a large gap between public and private innovation financing. Although restructuring of the Danish Growth Fund has been undertaken to alleviate this problem and make it possible for the Fund the pursue projects in later stages with more capital the gap still exists. As indicated above the situation for small SMEs is even more difficult.

Narrowing or even better, closing the gap would help a number to pass this "valley of death". One way to do it would be to establish a strong public/private fund focusing on the specific stages that are of interest to venture capitalists and private equity. This fund could invest in traditional sectors as well as in hi-tech ideas emanating from the innovation environments, science parks, universities etc. Establishing the fund would both increase the amount of risk-willing capital and bring funding of early-phase innovation in Denmark up to a level that is comparable to that of other leading countries.

Case studies

In the following four cases will be presented. The case studies aim at providing insight in problems, solutions and eventually uncover best practices in relation to establishing different type of relations between SMEs and academia.

To provide the reader with a comparative overview all cases will follow the taxonomy below:

- Basics
- History of the company
- Links with academia
- IPR issues

Company 1: Knowledge service industry

Basics

Company 1 is a consultancy firm specialized in the Human Resource area with a special focus on job transition management. Since the foundation of the company in 1989 Company 1 has provided consultancy services to a large number of businesses and institutions ranging from small companies to big international organizations from both the private and the public sector. The company is employing 90 people; of this 60 consultants are working at the 5 offices located in Denmark. In excess of that a similar number of freelance consultants are affiliated, offering their competences in different fields of the human resource area. At the moment approximately 1500 clients are using the different advisory services at Company 1.

History of the company

The three present managers founded the company in 1989. The kinds of services they are offering, e.g. different outplacement programs, were in the beginning primarily directed towards executives. Today the services are offered to a much broader part of the business world, from managers to unskilled workers. To keep updated on the demand for the services provided, the company is participating in a number of different boards and association in both industry and academe. In this way Company 1 anticipate creating a network of potential co-operation partners.

Links with academia

In the last couple of years it has been in the management's keen interest to establish a stronger relation to academia. This wish has been motivated by a growing need of expanding the company's basic knowledge especially in field of communication and learning. The university is seen as a potential partner on the invention of new generic concepts and service solutions, because of the expertise and knowledge they posses in some very relevant fields. As one of the mangers puts it: "the universities possess knowledge that would take us five years to produce".

In relation to a specific development project a university department was contacted. The department was recommended to one of the mangers by some of his network contacts. One of the main aims was to enable the company to extend the possible ways of using the existing services e.g. by use of IT, as well as getting knowledge

about the possible consequence of using different IT solutions as a part of the coaching program.

The attempt to establish a contact to the university department was experienced, as a bit of a struggle, and only after one month was Company 1 able to get in contact with ”the right man”, as they put it. The contact is seen as very dependent on personal relations and on finding a researcher at the university that is engaged and able to se the benefits of collaborating with a company. The fact that the process of establishing a relation to the academic world was so heel-dragging is seen as a major constraint, but still the benefits from the collaboration project paramount the problems in a way that makes it possible that Company 1 will do it again if the opportunity appears. One of the main lessons learned from this last collaboration project is that a huge network of contacts is essential to establishing research collaborations. It is hard to trace a committed researcher through the official channels, the informal contacts and acquaintances are much more likely to show the way to the right person.

After establishing a good relation to a university department one of the managers has experienced that the collaboration is very valuable. Besides the overall advantage of getting access to basic research in relevant fields Company 1 is benefiting from the relation in other ways as well. Especially the clients see the fact that Company 1 is having a close relation to academia when developing their products and services, as an approval of the company’s work.

IPR issues
Company 1 hold no patents on services or methods, and are not considering patenting to be crucial to the further development of the company. They are protecting their market position by maintaining a strategic lead. Company 1 expects that their collaboration with academia will help them maintaining the position.

Company 2: Voice technology

Basics
Company 2 is a small company working in the field of voice technology. The company is offering services and solutions based on voice recognition or ‘text to speech’ technology, all developed with special focus on the integration and use of state of the art Voice technology. One of the main goals at Company 2 is to support and commercially use the development in the area of Danish Voice Technology, to maintain and support the Danish language culture and to support a continuously high level of research and development in the area.

The company employs 5 people: the manager, two technicians, a sales person and a programmer. Due to the general exhaustion in the field of Information Technology, the manager will not be expecting any significant growth in the number of employees over the next years.

History of the company
Company 2 was founded on the basis of a Development Contract with the Ministry of Science, Technology and Innovation. The purpose of the development contract was to develop a high quality ‘Text To Speech’ (TTS) to enable usage in a lot of different

areas. Behind the development contract was a consortium constituted by a large Danish telecommunication company, a science park, and two university institutes, one affiliated at Aalborg University and one at the University of Copenhagen. The present manager of Company 2 has a previous career in the telecommunication company, and has for that reason a thoroughly understanding of the field, as well as a huge network of potential customers and R&D-collaboration contacts.

The company was from the beginning characterized by the gathering of research from the three different partners; the two university institutes and the R&D department of the telecommunication company. The research collaboration project that resulted in the foundation of Company 2 was built upon an already existing product developed and owned by the telecommunication company. The product was further developed using the research competence and know-how of the two university institutes. The telecommunication company and the science park are today the major investors and the main shareholders; the two universities hold a minority of shares.

Links with academia

The field of Danish voice technology is not yet a very commercial area, and for that reason it is not possible for Company 2 to get enough funds enabling them to internalize the research in the company, e.g. to co-opt researchers. The company is highly dependent on the universities as their main source of research based knowledge, and they are currently in regular contact with researchers from five different university departments or public research organizations.

It is a general hallmark of the field of Danish voice technology that the different research competencies, necessary for the companies to improve the existing products are scattered at universities all over the country, making it difficult to join people in connection to research projects. This dispersal of the different research departments is generally seen as a disincentive to the existence of research collaboration projects. The different cultural background of the university departments is another obstacle to the research collaboration projects with the university. The manager of Company 2 is expressing an overall experience of uncooperativeness among the different university departments, as well as a lack of appreciation of the more commercial focus of the company. This has resulted in the interruption of the collaboration with one of the university departments, which is now working only on a consultancy base.

In projects where the partners had a history of working together, the collaboration is eased a lot, even though the partners are often located at different localities. Earlier experience with this kind of research collaboration is a huge advantage to the projects. The fact that one of the employees at Company 2 has been working at different university departments, and thereby has created a network of contacts among different researchers, is also a benefit of the company.

IPR issues

LB considers patenting to be a crucial topic. Holding a patent is generally seen as an advantage to the company. However they hold no patents so fare, and find patenting way to expensive and time consuming. Their IPR strategy has been to publish any new services or software, to prevent others from applying for a patent on the results. Even though it is possible to apply for a patent on IT software in Denmark it is not very common to do so. In connection with research collaboration projects Company 2

has experienced, that the university researchers are uninterested in patenting because it restrains them from further elaboration on the research.

Company 3: Meat processing

Basics

Company 3 is a research institute owned by the industry organization of Danish slaughterhouses and thus by Danish pig and cattle producers. The primary aim of the industry organization is to safeguard and promote the interests of pig producers and the pork and bacon industry, through contributions in various areas such as: research and development, sales promotion and information, service, disease prevention and control. Regarding the research and development responsibility, this is fulfilled at the research institute. Apart from carrying out the research assignments, the institute is also offering services like development and maintenance of data systems, handling of library activities and monitoring patens, to the members of the meat association. It is the purpose of the institute to create a worldwide leading knowledge center in the field of meat research, and as such the institute can be seen as a joint research enterprise for a number of companies from the Danish meat industry. The Institute has a turnover of 170 Million DKr. including 48 million DKr. in revenue from their consultancy.

History of the company

Company 3 was established in 1954, financed with money from the 2nd World War, partly money derived from pre-war bacon supplies to England and partly government finances from the Marshall support. Strong characteristics, then as now, are the close connections to the meat industry and thus the will and wish to alter the activities according to the requirements of the industry. The institute has approximately 160 employees including scientists, technicians and laboratory technician, and has a wide range of collaborative partners throughout the Danish meat industry.

The institute is partner in a meat research forum where the research and development of the business is monitored and coordinated, concerning both the public and private areas of meat research. The main aim of the forum is to co-ordinate the strategies of the different players, thereby creating a strong, cross-disciplinary basis to future research and development projects. Furthermore the employees at Company 3 are participating in more informal and personal networks relating to the different fields of research. These networks are constituted both by researchers from academia and representatives from the industry, and through these contacts the researchers are able to locate new research partners.

Links with academia

In addition to the contact to the Danish meat industry, the Institute has always had a broad network with research institutions in Denmark and internationally, both with meat research institutes and in other areas. This has ensured the knowledge supply, which is necessary to complete the projects successfully. During the 90's Company 3 has had a major benefit from the Danish government's food technological research and development programme, which was partly designed to strengthen the cooperation between public research institutions and industry. Internationally,

cooperative research projects were also started as part of the large EU research programmes in the 90ies. Most recently, the Company 3 has agreed with Swedish Meats about taking care of their research and development activities. The Institute has participated in about 30 public funded research projects over the last ten years. Besides from participating in research collaboration projects the institute is also in contact with academia in many other ways, such as teaching university students, being external examiners and hosting trainees.

Company 3 can be seen as a link between public and private research, and it is considered a very important task at Company 3 to contribute to the creation of a closer relation between academia and industry. In relation to the research projects where people from both academia and industry join cross-disciplinary projects, management is seen as a very important issue. Bringing people together from different institutions and disciplines, handling the possible differences in culture and routines, call for a distinct line of management.

A way of securing that the best possible results are being obtained from the collaborative projects is to make sure that people from academia and industry engage in frequent face-to-face meetings. All meetings in the steering committee as well as between the researchers are held by turns of the participants, to ensure that everybody get a better understanding of the way things work at university and industry respectively.

IPR issues

Over the last ten years more than 70 patent applications has been submitted and more than 350 articles has been published on the basis of the research and development undertaken at the institute. A Technical Secretariat is currently considering whether it is relevant to apply for a patent or not, and are furthermore watching the field of patents, publishing a quarterly status on relevant patens taken by other research institutes. Even though the patent application process is time consuming the researchers at Company 3 regard patenting as a very important issue. It is seen as a natural part of the research process to consider the possibilities of patenting in relation to a research result.

Company 4: Medico-tech

Basics

Company 4 is a newly founded Danish medico-tech (medico technology) research and development company. The company is a spinout from the Technical University of Denmark (DTU), and was established in September 1999 based on results and experience gained from five years of research at DTU in the field of miniaturization of chemical and biochemical analysis.

The proprietary technology of Company 4 is built around a unique sensor, which enables easy-to-perform, precise diagnostics on a blood droplet from the fingertip. The development focus of Company 4 is on medical Point-of-Care diagnostic tests, which address important detection and monitoring needs within healthcare. As a response to the growing demand from patients for fast and competent answers and treatment, there is a strong move towards decentralization of medical diagnostic

procedures, moving them from the laboratory to the patient - to the Point-of-Care.

History of the company
The company was established in 1999 and the company founder received his PhD from DTU in 2000. In 2001 Company 4 moved from the buildings of the Technical University of Denmark to new office and laboratory facilities at Symbion Science Park in Copenhagen. The same year Company 4 obtained substantial funding from different Danish venture capital and institutional investors, and a new Chief Executive Officer was appointed. Simultaneously the founder was appointed Chief Technical Officer. In 2002 a Mechanics Development Manager and a Chief Scientific Officer was appointed, and the number of employees has by now reached 12, and is increasing by approximately one person monthly. Due to this speed in growing the company is expected to move to new and lager premises next year.

Links with academia
Due to the founder's background as a PhD. student at the Technical University of Denmark a network of researchers at different university departments primarily at DTU are available. But these contacts are mainly informal and no research- or development projects are being conducted in collaboration with university departments. This lack of collaboration is mainly due to the fact that the company has left the research-intensive stages and is presently working on the very product specific development. According to the founder's belief this kind of development is impossible to carry out in collaboration with others. Even though he finds the thought of keeping close contact with his educational basis very reasonable he is questioning the way such a contact could be managed. Company 4 has recently been engaged in a process of creating a center contract together with partners at DTU, but the attempt failed because the company didn't find the formal framework, e.g. the handling of property rights, to be compatible with their current stage of development. Some of the political initiatives, such as the center contracts, are regarded to be more in favor of larger companies than the small and newly established ones. Being a newly settled company solemnly based on financing from different venture capitalists makes it difficult to engage in long-term research and development projects with academia. The contracts with venture capital firms are often based on the premises that some specified timed conditions has to be meet; successive development stages or trances have to be fulfilled to gain further financing. In the opinion of company 4's founder these conditions are not consistent with the way the university-based research is conducted.

The founder is aware that his own background as a PhD student at DTU and the fact that the core research of the company was conducted there is an approval of very high value to the company, and he regrets that cultural and formal incompatibility of the two spheres; academia and industry, makes the collaboration difficult. Generally he is very positive about future possibilities of research and development collaboration projects, a collaboration that will however only be possible if some of the actual conditions at the universities are changed. He values presence of industry representatives at the university departments and practical training of engineers as essential to further collaboration. At the moment Company 4 is keeping in contact with academia by receiving students from DTU as trainees for shorter periods.

Due to closeness of launching the final product, the present collaboration partners are found in the healthcare sector. The final product is expected to reach the market in approximately two years, and in order to ensure that the unique sensor technology is applied to the key diagnostic challenges of healthcare; development at Company 4 is conducted in close collaboration with opinion leading medical specialists as well as nurses and the patients themselves. Some projects are also carried out in collaboration with the Danish Technological Institute.

A huge work pressure makes it very hard for the founder to find the time to participate in the formal or informal networks existing in the field of medico technology, even though this kind of business is regarded important.

IPR issues
The research has lead to the application of four patents, of which two are granted, and the founder is regarding patenting highly important. The wish to protect the development of new parts of products or technological solutions is continuously resulting in new patent applications. Furthermore the patent literature is often scanned to make sure that no one is threatening the company's patents and to get an understanding of the trends of the medico-tech field.

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Chapter 4: Country report: Finland

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Introduction

In the 1990s, public funding for research increased in most OECD countries. This is especially true in the case of applied research, although there was some increase in the attention paid to basic research at the end of the decade. In parallel, there is increasing pressure to realise results from the allocated resources. In Finland like in other OECD countries, SMEs are considered increasingly as being the driver of country's economy; SMEs account for 99 percent of the total number of companies, for two-thirds of employment. Because of the obvious economic significance of SMEs in terms of employment and value added, R&D policy throughout the world has been concerned with the specific needs of this group of enterprises (European Commission Research 2003). Enhancing competitive advantage of existing companies by providing incentives for increasing investments in R&D and stimulation of research based spin-offs have been seen as means of increasing the effectiveness of the public funding and, overall, as a way of ensuring the commercialisation of research results.

Inevitably, there are many dimensions of public policy that affect the performance of commercialisation of research results and SMEs' innovations. These include financing policy, education policy and regulatory policies. In practice, the public policy actions can enhance technology diffusion between actors, and to increase the absorptive capacity of these companies. Especially the financing and education policies have been in the focus of Finland's R&D policy since the early 1990s. In addition to promoting networking activities between research organisations

and enterprises, increasing attention has been paid on changing the thinking in universities to make it more market oriented, as well as allowing commercial and strategic considerations to influence the direction of research. Also, practical help with business start-up, management, risk assessment and financing and IPR management has been offered.

This chapter is based upon empirical findings in the literature and policy documents concerning policy actions in promoting commercialisation of research and SMEs innovations. It aims at identifying a set of general trends and public support practices for the commercialisation of academic research and the promotion of the growth and development of small and medium sized enterprises (SMEs) in Finland. The aim is to understand key processes and practices in commercialising research and to clarify the manner in which current government innovation support schemes cater for the various needs that exist within the innovation system. The focus of the report is on the institutional, regulatory and cultural (=attitude) factors that influence the commercialisation of academic research as well as on the role of public research organisations in technology transfer and the innovation process.

The report is structured as follows: after the introductory section, Section 2 outlines on the general background of the Finnish industrial structure and economy and then explores R&D profile of industry. Section 3 illustrates the nature and structure of the Finnish innovation system, its major public actors and recent trends in public R&D. The same section provides also an overview of the policy initiatives that promote linkages between public research organisations and industry and commercialisation of research especially from SMEs perspective. The case stories that illustrate views of Finnish SMEs on the linkages with research organisations and

IPR matters particularly are shown in the section 4. The final section concludes the major lessons to be learned from the Finnish case.

Finnish Industry and Innovation

For some years, Finland has been in a phase of higher economic growth than the average for the EU, whilst unemployment in the country has been diminishing. Unemployment is still at a high level internationally (8 per cent) while inflation is at low level (1.6 per cent). Despite the fact that Finland's economy performed well in the late 1990s, the pattern of economic growth has become uneven and is showing a downward trend in the early 21st century. Finland operates in an open market that makes its economy vulnerable to the trends of large economies such as Germany and the US. Hence, developing a high technology base, promoting its effective utilisation and deploying determined efforts to increase exports are necessary requirements to improve Finland's position in terms of international competition. Also, a major challenge for the future is to ensure that Finland remains sufficiently attractive for business and jobs, and as a living environment, in circumstances of increasing global competition.

In Finland, the importance of innovation and production of new knowledge is widely recognised. Throughout the 1990s, the education and industrial policies were developed towards supporting innovative performance. At the same time, the industrial structure was specialising in knowledge-intensive, high-growth sectors and products (Ormala 1999). Today, one characteristic of the Finnish research and innovation environment is that, in international terms, a large proportion of research is carried out by private enterprises. In 2001, the bulk of research and development in Finland was carried out by businesses using their own funds, accounting for approximately 70 per cent of the national R&D effort. Another characteristic is that

private sector research is dominated by large companies, and by the electronics industry in particular, mainly due to Nokia's influence.

Overall, Finland is receptive to new ideas and continues to feature exceptionally strongly in various technology development rankings. According to the recently published EU Innovation Scoreboard (2001), Finland is the second most innovative country in Europe after Sweden, with special strengths in enrolment in tertiary education, per-capita patenting in high-technology, and business and public spending on R&D. However, it performs relatively poorly in terms of turning new ideas into commercial successes. Also, in terms of entrepreneurship, Finland needs to do more to provide a supportive climate, and overall remains relatively averse to risk-taking. The same report indicates a lack of innovative small and medium-size firms as a weak point in the Finnish innovation system. The main bottleneck, as some Finnish key informants see it, is more in the area of technology commercialisation. Whereas large Finnish companies have excellent strengths in this area, creating viable technology-based new ventures is problematic. Indeed, there are very few management teams with such experience in Finland at the moment (Arenius et al. 2001).

It has often been noted that there are particularly high barriers in the way of small and medium-size enterprises seeking technology input from universities and technical research centres. For universities, large firms are more attractive partners, since the cost of starting a new project is almost constant regardless of the size of the project. It has become important to discuss the role of public research organisations in assisting and enabling small and medium-size firms to have access to new technology. It is likely that large Finnish companies cannot broaden their production in Finland but are transferring their activities to countries where labour is cheaper.

Thus, nurturing world-class, technology-based new firms and strengthening the innovation capabilities of SMEs is reckoned to be a respectable source of job creation and is vital in boosting economic growth.

Another policy issue is related to the entrepreneurial framework conditions in public research organisations. In the university sector, much progress has been made in setting up technology transfer and innovation offices at universities. However, these still remain at an early phase of their learning curve. Furthermore, the regulations and, in particular, practices concerning the intellectual ownership of inventions made by university personnel remain unclear. Currently, the law regarding university inventions is undergoing reform aimed at clarifying practices and rules in the intellectual ownership of invention, and intensifying the commercialisation of research results (this will be discussed later in more detail). The revision of the law is an indication of the changing role of universities and they are pushed toward the centre of economic systems. This development is also reflected in increased collaboration with industry and in the rapidly increasing share of external funding as a source of funding.

Finnish industry and economy

The past two decades have witnessed a remarkable structural change in Finnish economy. During the 1990s Finland became a major exporter of electronics and other high-tech products, which by the year 2000 accounted for over 30 % of exports. Manufacturing and exports in relation to total output has dropped steadily. Still a significant part of the Finnish economy continues to rest on manufacturing or service activities that are traditional as opposed to knowledge-intensive industries. While the Finnish industrial structure has changed dramatically during the 10–15 years the firm size has changed much less. The company structure in Finland is very much the same

as elsewhere in Western Europe. The SME sector, especially micro sector, is large while the number of multinationals is low. In 2000, SMEs[77] in Finland accounted for at least 99 per cent of firms in manufacturing, utilities and the main service sectors for which data are available. SMEs accounted for 69 per cent of the total workforce and 50 per cent of turnover for all these sectors.

Table 4.1: Finnish Enterprises, 2000

Size of enterprise	Enterprises		Personnel		Turnover	
		%	1 000	%	€ million	%
0-9	207 004	92,9	320	24,6	43 088	16,4
10-49	13 014	5,8	250	19,2	42 351	16,2
50-249	2 237	1,0	224	17,2	47 108	18,0
250-499	296	0,1	104	8,0	26 650	10,2
500-	266	0,1	403	31,0	102 798	39,2

Source: Statistics Finland, Business Register

One of the problems in Finland is the small size of SMEs. A recent financing inquiry by Finnvera on SMEs, which covered 3000 companies, shows that only 8 per cent of SMEs were actively seeking growth. Less than half considered growth subject to favourable conditions and about 45 per cent had no intention of seeking growth.

SMEs and innovation

SMEs are actively looking for ideas, knowledge and partnerships from several directions. The most important partners are their customers, equipment suppliers and subcontractors. Universities and public research institutes come much later. Studies on firm-level innovation processes have indicated that the propensity to cooperate with universities depends on the regularity of in-house R&D activities together with the company's technological level (e.g. Faulkner et al. 1994; Nieminen & Kaukonen 2001). It is widely known that SMEs cannot afford to invest in their own research and

[77] The SME definition used includes firms employing up to 249 employees.

development or hire research staff. Therefore, collaboration with public research organisations can be a valuable means of keeping abreast of technological and market trends, and also of acquiring advice on implementing new technologies.

Data collected by VTT (SFINNO-data) and the Community Innovation Survey (CIS2) provide an indication of how innovative Finland's SMEs are relative to larger firms. The SFINNO data indicates that SMEs are more dependent on public support for innovation activities than larger companies. While in the second half of the 1990s around 78 per cent of SMEs reported receiving public support for the development of innovations, a little over 55 per cent of large companies did so (CIS2). If we compare these numbers to the first half of the 1990s, the recent developments have not favoured the innovation activity of SMEs. During the period 1990 to 1994, the corresponding numbers were some 83 per cent for SMEs and 44 per cent for large firms (more than 100 employees). More specifically, the biggest losers seem to be those micro-firms with less than ten employees (from 88 to 80 per cent), whereas the large firms with more than 1000 employees have progressed the most (from 38 to 60 per cent). Still, SMEs receive relatively more public support for the development of innovations than the larger firms.

The SFINNO data also contains information on the factors contributing to the origin of the innovations, ranging from the nature of competition, markets and demand-driven factors, science and technology, to various public sector activities, regulations, legislation, standards and licenses. According to the data, market-related factors have played an important role for the origin of the innovations in more than 90 per cent of cases. The demand of customers was regarded to occupy the second place, in more than 70 per cent of innovations commercialised by SMEs. Customers were also important as the collaborative partners during the development of innovations. In

almost 60 per cent of innovations, the role of customers in the development process was seen as important. This relatively high number might give some indication of the role of contract-manufacturing, not necessarily of an active involvement in the development projects of different kind. In addition, the importance of subcontractors is invariant (some 25 per cent) across the firm size groups, whereas the importance of VTT (Technical Research Centre of Finland) and consultants decreases as firm size grows. (see Palmberg et al. 2000)

R&D in the business sector

The development of a knowledge-based economy is expected to result in a larger share of high-tech industries in the business sector. Scientific and technological knowledge is especially important in the high-tech industry, but will also become increasingly important for medium-tech and even low-tech industries. By international comparison, the share of high-tech industries in business sector R&D investment is noticeably higher in Finland (61,4 per cent) than the EU average (41.5 per cent) or the US average (45.8 per cent) (OECD).

In 2000, almost 2,500 Finnish enterprises with more than ten employees were engaged in R&D actions. Over one third of these were enterprises with 10 to 49 employees. As mentioned above, R&D is heavily concentrated in large enterprises. These companies accounted for 71 per cent of total R&D expenditure in the business enterprise sector, the electronics industry accounting for the largest share of business R&D expenditure (54 per cent). (Statistics Finland)

Measured in terms of innovative firms, the most innovative industries in Finland are the electrical and optical equipment industry (70 per cent) and chemical industry (63 per cent), whilst the least innovative industries are the transport equipment industry (34 per cent) and food industry (35 per cent) (Statistics Finland

2002). In addition, the last decade has witnessed a rapid growth of a new innovative industrial sector, namely the software sector. The size distribution of software innovating firms is skewed towards small firms, whereas in other technologies it is relatively even. Firms with fewer than 10 employees produce about 40 per cent of all software innovations, which indicates a rather specific characteristic of this industry. Despite the burst of the "bubble" in the early 21st century, the software sector has, since its early beginning, been based on innovative products and solutions, which serve the other industrial sectors as well.

The associations between company size and innovation have been researched in VTT project and in CIS2 (Statistics Finland 2001). In the manufacturing sector, both the number of innovating firms and the share of **innovative turnover** increases steadily with company size. In service industries, the differences are not as evident. In fact, in the service sector, the share of turnover attributable to innovations is highest in small firms with a staff of 10 to 19. This may reflect the fact that small companies are usually founded in order to produce only one specific innovative service concept, whereas manufacturing firms might have plenty of innovative products in production simultaneously.

However, if we turn our focus to the role of **individual innovations**, the results indicate that the contribution of innovation to turnover diminishes as firm size grows. 61 per cent of the innovations originating from firms with 1 to 9 employees account for over 50 per cent of turnover, and this share drops rapidly when moving towards the bigger firm size groups. In the larger firm size groups (10 to 99 employees) the share of innovations accounting for 0 or 1 to 5 per cent of turnover increases correspondingly. The phenomenon described above is rather similar both for the manufacturing and service industries. (Statistics Finland 2001)

Patenting and protection of intellectual property

Finland is one of the countries that have registered a ratio of patent applications relative to population above that for both the EU and US averages[78]. In terms of patents applied for at the EPO, Sweden (306), Finland (283) and Germany (270) were at the top in terms of recorded number of patents per million population in 2000.

Finland has also been active in domestic patenting. Companies and associations filed more than two thirds of all domestic patent applications. In 2000, the number of business enterprises filing patent applications was 612. By international standards, the share of private individuals is comparatively high in Finland (31 per cent). This is largely explained by the applications filed by university researchers (Statistics Finland 2001). No systematically gathered data is available on patenting by universities or public research organisations. However, it has been estimated that university researchers in Finland file some 80 to 140 patent applications each year (The State and Quality of Scientific Research in Finland. Publications of the Academy of Finland 7/00, p. 107.) The Technical Research Centre of Finland (VTT) is the most active single public research organisation in patenting. By October 2002, the number of filed of accepted domestic patents originating from VTT was 148, whilst the figure was 255 for foreign patents.

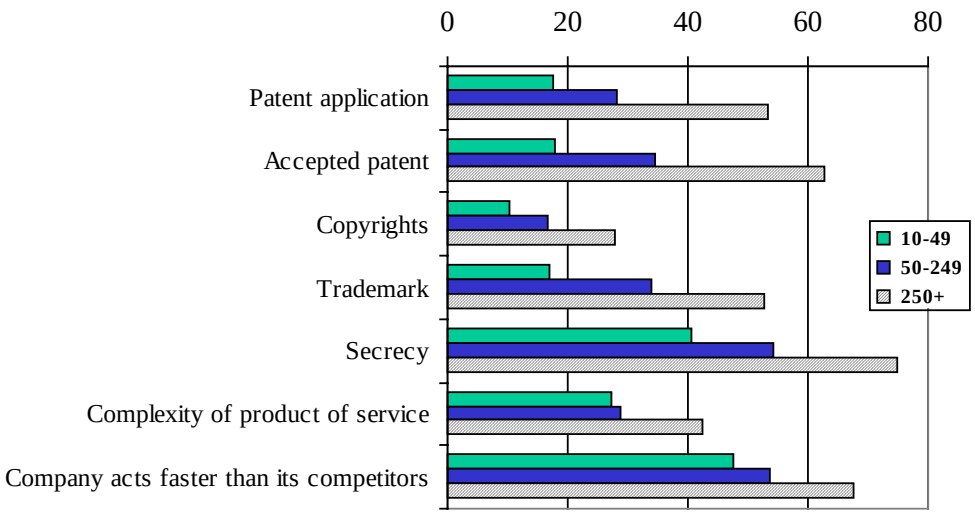
Patenting is heavily concentrated. In 2000, the largest single category of domestic patent application was the electricity sector (24 per cent). Among the foreign applications, the largest category was chemistry and metallurgy, accounting for 24 per cent of all applications. The breakdown of patent applications in Finland by more detailed technology shows that both domestic and foreign patent applications were concentrated in the field of telecommunications (19 per cent and 18 per cent

[78] Statistics Finland

respectively). In 1999, the regional breakdown of patent application shows that region of Uusimaa accounted for 39 per cent of all domestic applications filed by businesses. Three other regions, Pirkanmaa, North Ostrobothnia and Central Finland accounted together for 30 per cent of the total.

The Innovation Study 2000 (Statistics Finland 2003) provides further information about the use of various protection methods. Figure 1 shows that in the industrial sector, the use of protection methods for intellectual or industrial property is more common for larger than for small or medium-size enterprises.

Figure 4.1. The methods of protection of intellectual property in industry by size of firm (%).



Source: Statistics Finland, (2002)

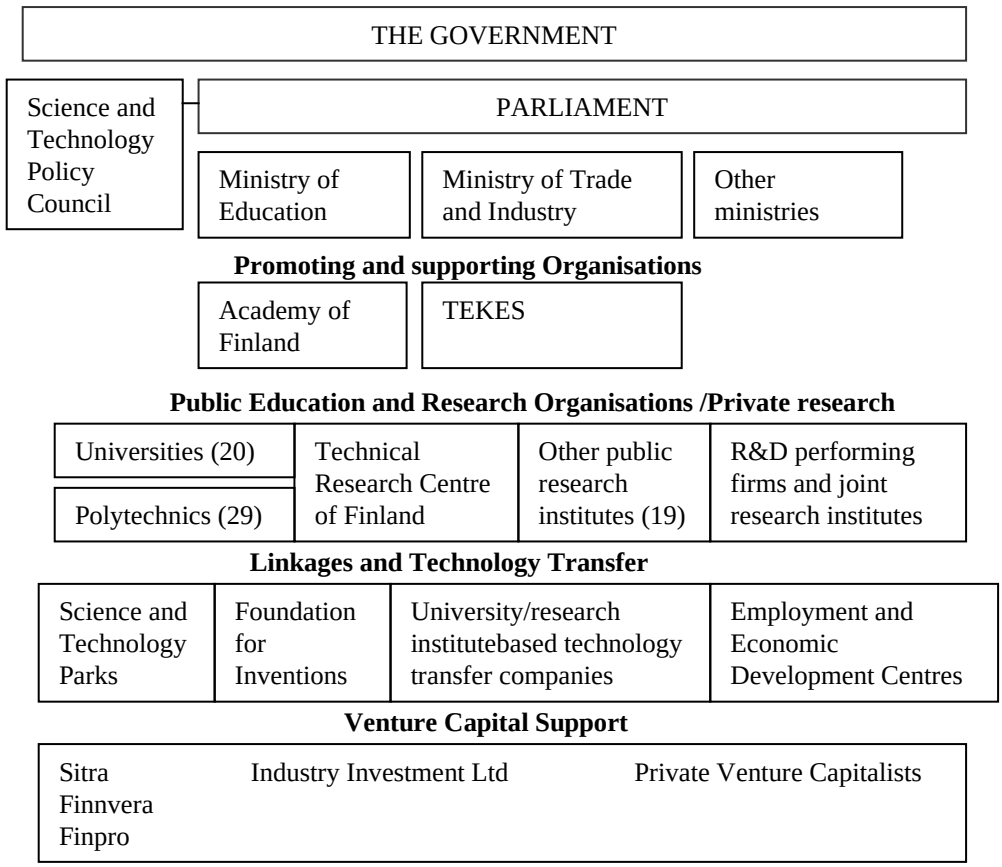
Also, the protection of intellectual property is more common in innovative firms (74 per cent) than non-innovative firms (21 per cent). The most often mentioned methods for protection were the company's faster rate of activity compared to its competitors,

and secrecy. In other branches, no major differences were found between SMEs and large companies in the use of protection.

Public R&D structure

The two most important ministries in the Finnish national innovation system are the Ministry of Education and the Ministry of Trade and Industry (see Figure 4.2 below). Responsibility for innovation and SME policy-related questions resides with the Ministry of Trade and Industry (MTI), which implements SME policy in close co-operation with other relevant ministries and organisations. The Science and Technology Council of Finland, chaired by the Prime Minister, is a key organisation in formulating science and technology policies.

Figure 2. Organisations in policy design and implementation



Tekes, the National Technology Agency, established in 1983, has a prominent role in promoting the commercialisation of research in Finland and the linkages between public research organisation and SMEs. It provides funding and expert services for R&D projects at companies registered in Finland at Finnish research institutes and universities, and promotes national and international networking. In making the funding decision, Tekes takes a positive view towards projects that involve networking with other companies, joint ventures, use of local SME subcontractors in the case of larger companies, participation in national technology programmes, contracting of services from Finnish research institutes and universities and the promotion of international co-operation. In addition, Tekes takes part in the planning of Finnish technology and innovation policies along the lines given by the MTI.

The Technical Research Centre of Finland (VTT) is another significant body in the administrative field of the Ministry of Trade and Industry. VTT is an impartial expert organisation that carries out technical and techno-economic research and development work. According to the recent impact studies, collaboration with SMEs was regarded as one of the major challenge for VTT in the future. According to stakeholders, VTT should put more emphasis on collaboration with SMEs in traditional branches and enable them to have access to new technology. (Kutinlahti & Hyytinen 2002; see also Oksanen 2003)

The administrative field of the Ministry of Education covers all 20 universities, a network of polytechnics (29) and the Academy of Finland, which includes four national research councils. In addition, the Ministry of Education and the universities together maintain the basic services and infrastructure (e.g. scientific libraries, archives and supercomputing facilities) for the national research system.

Universities are responsible for basic research, but increasing attention is being paid to the relevance of university research from the point of view of the business sector and society. All Finnish universities are state-run, with the government providing some 70 per cent of their funding. The emphasis in university research and in its funding has been on the high quality of research and on the development of internationally competitive centres of excellence and researcher training. At present, there are 147,000 university students, of whom 19,000 are doctoral students. A network of 29 polytechnics is becoming an important source of research. In 2001, circa 121,500 students participated in degree programmes in polytechnics.

At a regional level, technology centres, science and technology parks, centres of expertise, and other similar operations (e.g. Foundation for Finnish Inventions and technology transfers companies) form a supporting expertise network which provides advice on matters relating to the development of inventions, their patenting and related strategy. Finnish science parks are operational environments for state-of-the-art technology, with direct links to the highest education and research in their own regions. Science parks provide premises, services and an opportunity for success for both high-tech start-up companies and more established businesses. The Foundation for Finnish Inventions is a state-owned organisation that supports and helps private individuals and entrepreneurs develop and exploit invention proposals both within Finland and internationally.

Historically, the Finnish Business Trade Promotion Organisation (Finpro) has the longest history of the government organisations promoting SME innovation activities being established already in 1919 to promote Finnish exports. The currently active institutions providing SME finance were established during the two waves of government activity of government activity. The first ware began already in the

1960s, when the Finnish capital markets were heavily regulated. The Finnish government together with the Bank of Finland established a semi-governmental venture capital firm, Sponsor and Sitra, in 1967. In 1971 the Fund for Developing Regions, known as Kera and today as Finnvera was founded to subsidise businesses and provide loans especially to firms residing in the less developed areas. Establishing Tekes in 1983 completed the first wave.(Hyytinen & Väänänen 2002)

The second wave of government activity begun when a new government venture capital firm, SFK Finance Oy, was established in 1990 by Kera. In 1991 Sitra was separated from the control of the Bank of Finland and transferred to under the supervision of the Parliament. The government venture capital firm Finnish Industry Investment (FII), was established in 1995 to promote the development of venture capital in Finland. In 1997, TE-centres were established. The centres implement innovation activities at regional level alongside with several other tasks related to regional development. The organisation of TE-centres is perceived as functioning well by the SMEs for its proximity to industry and regions. However, its role in the national innovation system is blurred because it has to meet both national and regional expectations. The second wave was completed in 1999 to promote the State-owned specialised financing company Finnvera was created through the merger of Kera and the Finnish Quarantee Board. (Ibid. 2002)

Financing for SMEs also flows from the budgets of various ministries through regional EEDCs and from various regional governmental and semi-governmental venture capital firms. On the whole, these institutions provide SMEs with financing via a variety of tools, including grants, loans, direct subsidies, aid packages and guarantees. It is to be noted that even though there has been some privatisation of

publicly funded initiatives in recent years, publicly initiated actors still play a significant role in the Finnish venture capital industry (Seed capital ...2002).

The Finnish innovation system seems covers different phases of the innovation chain. It has been noted, however, how well the existing services and organisations match the needs of companies and support effective innovation structure. The evaluation study of Finnish innovation support system (Ministry of Trade and Industry 2003) points to the overlaps between the public sector organisations, and between public and private sector. This was one of the areas where the relatively well functioning system could evolve into something even better than it is today.

R&D financing

One of the most prominent trends in Finland has been the rapid increase in both public and private research funding during the 1990s. At the same time, there has been a strong commitment to raise quality standards and invest in higher education and in postgraduate training. The share of GDP spent on R&D expenditure increased from 2.0 per cent in 1991 to 3.4 per cent in 2001 and is now among the highest in the world. Also, know-how and education are considered to be the main building blocks of economic growth, employment and social welfare. In 2000, a total of 70,000 people were involved in research and development, over half of whom in business enterprises, 30 per cent in the university sector and 16 per cent in the public sector.

The increase in R&D expenditure is chiefly explained by increased R&D investment in the business sector. Investment has also grown in the public sector, but its share of Finland's total R&D expenditure has dropped to less than 30 per cent. The growth of R&D expenditure in the business enterprise sector has occurred almost exclusively in business enterprises in the electronics industry. In real terms, R&D

spending in the electronics industry in 2000 was almost six-fold that of 1991, whereas in other manufacturing the increase was 1.3-fold and in industries other than manufacturing, three-fold. It is estimated that Nokia's share of total R&D expenditure in Finland was roughly a third in 2001 and Nokia's share of the business sector R&D expenditure was about 47 per cent (Ali-Yrkkö & Hermans 2002).

Public R&D funding showed particularly strong growth in the period 1997 to 1999. This was a direct consequence of the government's 1996 decision to invest an additional FIM 1.5 billion into scientific research by the end of 1999. The extra funds were especially intended to help improve the innovation system with a view to strengthening the economy, creating new business and generating new jobs. In the public sector, the increase in funding has been channelled through Tekes, while the Academy of Finland has also increased its contribution in real terms. While budget allocations to universities and government research institutes have remained largely unchanged, increased external project funding has provided them with more resources (Tuomaala et. al 2001).

In universities, R&D funding provided by business enterprises to universities tripled from 1991 to 2000. The figures below show, however, that the most significant single funding sources for university research are public funding agencies, whereas in comparison companies have a relatively modest position, around 12 per cent of all external funding.

Table 4.2: External funding of university research by source of funding 1991-2000 (%).*(Source: Statistics Finland)*

	External funding	Academy of Finland	National Technology Agency	Ministries	Firms	EU	Other*
2000	438363	25	20	26	12	7	10
1998	272778	29	23	15	12	7	13
1995	175519	37	16	16	16	2	13
1991	132981	42	11	16	12	0	19

Other: municipal funding, other public funding, domestic foundations, international foundations, other international funding, universities' own assets.

The significance of business enterprise funding is greatest in the field of engineering and technology, where it accounted for over 18 per cent of all extramural funding in 2000. Tekes' technology programmes, the cluster programmes and EU framework programmes have been important means of financing and strengthening the networking (see also Nieminen & Kaukonen 2001; Niskanen 2001).

Regionally, R&D expenditure is concentrated in four growth areas. The four biggest regions, Uusimaa (Helsinki, Espoo), Pirkanmaa (Tampere), Pohjois-Pohjanmaa (Oulu) and Varsinais-Suomi (Turku) accounted for 80 per cent of the overall R&D expenditure in 2000. The importance of also having an R&D presence in smaller regions has been clearly demonstrated by the authorities. The main policy intervention is channelled through the Employment and Economic Development Centres, established in 1997, the main tasks of which are increasing the awareness regarding the research policy and the establishment of networks and linkages between public research and industrial R&D. Regional development is based on the strengths of each particular region.

Universities and commercialisation of research

Universities are increasingly taking part in the commercial utilisation of research results. The salient role of universities as a source of economic growth and innovation sets new demands for the protection of intellectual property rights. The institutional and regulative framework on intellectual property rights in universities are, however, recognised as barriers for the effective utilisation of research.

In May 2002, the committee proposed the reversal of the Act of Employees Rights and a reform of the University Act (Ministry of Trade and Industry 2002). Under the existing Act, the inventor owns the rights to his/her invention but this right is transferred to the employer. However, researchers and teachers in universities or similar scientific institutions are not covered by the Act. Hence the basic rule is that the researcher owns the invention. According to the new proposal, the researcher and teacher exception rule would be reversed, meaning that university researchers would be in the same position as any other employee. If this rule comes into operation, universities could take over the rights for inventions in joint projects carried out in collaboration between themselves and a third party. The new Act would not cover the intellectual property rights in free academic research, where the inventor has the right to decide the primacy of publishing and utilisation of his/her invention. However, the Act would be contractual: the regulations would be applied if not contracted otherwise by the parties involved.

The committee proposal also includes the clarification of the legal issues that would enhance the overall framework for innovative activities and their establishment as a third basic mission of the universities along with education and basic research. Under the proposal, the utilisation of research results is included in the functions of the universities.

The proposal for the new Act regarding the protection of intellectual property rights in universities would change the current incoherence within universities and other public research organisations. The amendment would also bring the IPR practice in Finland closer to the prevailing practice in other member states of the European Union, the US and Japan.

In recent years, power has been delegated to the universities, which has increased their autonomy in internal management. Consequently, universities have developed and introduced new strategies and formal mechanisms to promote innovation activities in their organisation. One external factor that influences all Finnish universities and their policies towards academic entrepreneursip is, that the Ministry of Education points out the aim of increasing the share of external finance in university budgets.

In promoting the commercialisation of academic research, increased coherence and networking between the relevant organisations (Tekes, Sitra and the Academy of Finland) has been identified as an area for further development. The planning and costs of commercialisation should be integrated with research projects. In parallel with the reform of IPR legislation, competencies about IPR issues should also be strengthened among university administration and staff.

Protecting intellectual property in research organisations

The policies supporting the commercialisation of research in universities and public research organisations are divergent. For instance, VTT and Helsinki University of Technology have adopted a more rigorous IPR strategy while many other universities and research institutes are still in the learning phase.

Observations[79] regarding the implementation of IPR policy at VTT indicate that a general policy for the protection of intellectual property at an organisational level is difficult to apply for different fields and does not guarantee the effective commercialisation of research results. However, a common policy for commercial activities has increased the awareness of the need for protecting results and also the potential economic utility of the research. The research environment, attitudes of

[79] These findings are preliminary result from the study carried out by Kutinlahti & Elo, which analyses the implementation of IPR policy at VTT.

leaders and customers towards ownership and protection of intellectual property and also personal rewards for participating in commercialisation affect the way in which researchers have adopted the new policy targets (e.g. more aggressive commercialisation of research). Thus, informal principles and rules, tacit knowledge of patenting and other forms of protection of intellectual property play an important role in the management of IPR. Also, the early recognition of the potential commercial utility turned out to be an important factor in managing the commercialisation of research. The increasing cost of protecting IPR within VTT was seen as a growing concern of the staff. Some researchers were also concerned about losing research contracts with important customers because of attempts to keep the rights with VTT.

Most universities have internal consulting services and invention advisors[80] to assist researchers in innovation issues (innovation, EU, contract services etc.). One of the problem regarding the invention advisor system is that sometimes the invention advisor is not employed by the university but by the Finnish Foundation for Inventions. Thus, the advisor is subordinate to private labour law and not the law pertaining to civil servants, which may cause problems in the interpretation of regulations. Also, the non-disclosure agreement may prohibit the invention advisor from releasing any business secrets to his employer or colleagues at the universities, even if this was needed. Conflicting legal frameworks may hamper the legal status of the clients. (Lampola 2002)

[80] **Invention advisors** of Finnish Foundation for Inventions provide advice to individual inventors on technology, the development of inventions and on marketing. The experts are primarily from universities and research institutions, and abide by the confidentiality, which is a principle of the Foundation. The network of invention advisors covers the whole country and there are currently 16 advisors in TE-centres and 12 in universities.

The regulations on equity investment by research organisations in firms are also regarded as an obstacle to the commercialisation of research. A government organisation getting funding directly from the state's budget may not invest in the private sector without the specific consent of the Parliament. However, several universities have their own foundations that are able to make equity investments. These foundations have made equity investments in technology transfer companies together with the National Fund for Research and Development (Sitra) or in regional development companies jointly with other regional organisations.

Public initiatives for promoting commercialisation of research

The Finnish government has established a number of support mechanisms that aim to promote innovation activities in firms and linkages between academia and industry and to strengthen the ability of SMEs to absorb technologies and know-how. Most of these public measures have been drawn up during the 1990s. In the following, the policy instruments for strengthening academic-industrial links and the capabilities of SMEs are illustrated in more detail.

Promotion of clustering and co-operation for innovation

The extension and strengthening of network co-operation is seen as one of the key questions in the development of the innovation system in Finland. A number of projects and initiatives have been created to promote the transfer and utilisation of knowledge. Recently, there have been two major initiatives to promote cross and intra-sectoral collaboration in particular. The first initiative, *the Centre of Expertise Programme,* is a national measure that aims to enhance regional competitiveness by strengthening innovation, renewing the production structure and creating new jobs within the expertise areas selected. The second initiative, *the cluster programmes,*

initially funded through the programme for additional R&D funding aims to support R&D activities that strengthen clusters and collaboration between the industry and public organisations as well as company to company co-operation including user-opinion.

In its assessment of the additional appropriation for research, the evaluation group found that the cluster programmes have already initiated a degree of productive co-operation. The report also pointed out that development needs for the programmes seem evident: more focus should be given to the objectives, co-ordination between financiers should be improved, and the reporting requirements are too complex. As a conclusion, the evaluation group recommended that clusters should be extended to new areas and that the existing clusters need to be more focused. (Prihti et al. 2000).

Clustering and co-operation for innovation are also important elements of Tekes' technology programmes. Tekes takes a positive view of projects that involve networking with other companies, joint ventures, the contracting of services from Finnish research institutes and universities and the promotion of international cooperation. In the case of larger companies, one of the criteria for funding through technology programs is networking and the use of local SME subcontractors.

Start-up of technology-based companies

Initiatives aimed at the start-up of technology-based companies primarily relate to the venture capital industry and various incubator schemes. The Finnish private equity and venture capital market has experienced significant growth in terms of both investors and operations. The growth has also resulted in an increase in the number of members of the Finnish Venture Capital Association (FVCA)(http://www.fvca.fi). Today the membership covers a total of 50 private equity houses and venture capitalists. The association has 63 associate members.

The real growth of the association began in the latter half of the 1990s. Despite a downturn in international economics, the Finnish private equity industry has remained vital.

Governmental agencies have pioneered the Finnish private equity investing. In the end of the 1990s many private management firms had become prominent players. Today, the private sector accounts for most of the markets. The public sector is focusing mainly on seed financing and in rescue or turn around. The Finnish private equity market is also getting more international. For example, some Finnish venture capitalists and private equity houses have penetrated to Scandinavian markets. Also international private equity houses have found Finland and have established themselves in the Finnish markets.

The most significant public venture capital organisations are Sitra and Finnvera. According to a recent study, government funding, directly or indirectly, is still a main contributor to the Finnish seed capital segment (Seed capital investment in Nordic countries). Sitra played a significant role in the establishment of the Venture Capital Association in 1990. Sitra’s own activities include technology transfer and venture capital investments in emerging and technology-based start-up companies as well as spin-offs from large companies. Sitra's PreSeed service package has been created to accelerate the emergence of new technology-based businesses, improve capital management and introduce companies to the providers of further funding, including private venture capitalists. The PreSeed service consists of two measures: LIKSA and INTRO.

LIKSA is a joint funding service operated by Sitra and Tekes that can be used to obtain information and services related to the commercialisation of technology and the development of relevant business plans. The INTRO service takes care of the

efficient presentation of start-up enterprises so that they can find both institutional and private investors who might be prepared to provide simple, straightforward funding in the future.

LIKSA and INTRO are closely related to the Tekes TULI-programme, which was modified before the start of a new programme period from April 2002. The main goal of the TULI-programme is to promote new, technology-based businesses coming from applied research in Finland. The focus of the scheme is in the R&D activities at universities and research institutes. In practical terms, the aim is to transfer the commercial potential of research projects towards commercialisation and new ventures. Finnvera's domestic development and financing solutions are particularly geared towards SMEs and help to promote regional policy objectives as well (http://www.finnvera.fi).

The incubator schemes have been established in close association with the regional technology parks and universities since the late 1980s. The more significant ones include the Spinno scheme in the Helsinki region and the technology or company centres in the larger cities of Tampere, Turku and Jyväskylä.

The government's Entrepreneurship project, started at the beginning of 2000, was completed in the early 2003. It was carried through co-operation between nine ministries and the Association of Finnish Local Authorities. Most of the more than a hundred actions included in the project have been implemented. The project included various measures, which set out to increase the establishment of new firms and increase the growth and competitiveness of existing enterprises. The focus of the project was on different phases in the life cycle of a company. Measures taken to improve the environment for entrepreneurship have focused on the administrative obligations involved in running a business, financing, competition, social security for

the entrepreneur, counselling and development services for businesses, and further on improving the operating environment in the social welfare and health care services, the transfer of business ownership to a successor and bankruptcy regulation.

Intensified co-operation between research, universities and companies

Close co-operation between companies, research organisations and universities is considered a specific strength of the Finnish system of innovation. The single most important ongoing activity within this field has been Tekes' national technology programmes. The technology programmes aim to gain new technology expertise and product development options in the important business areas of the future. The programmes also offer good frameworks for international R&D co-operation. The technology programmes are demand-oriented in the sense that they have been planned with the needs of companies in mind, and have been implemented in collaboration with companies. The planning takes place in workgroups and seminars involving firms, universities and research organisations, and the explicit aim of the programmes has been to promote collaboration between these parties. Each programme has a steering group, a co-ordinator and a representative from Tekes. Universities of technology and the Technical Research Centre of Finland (VTT) have led most of the programmes. The duration of the programmes ranges from three to five years and their average volume ranges from €5 to hundreds of millions. Tekes usually finances about half the costs of the programme. The programmes have also functioned as good frameworks for international R&D co-operation, e.g. within the EU's framework programmes.

The achievement of programme objectives and the success of projects are evaluated and systematically both during implementation of the programmes and after their completion. Interim evaluations help to steer the programmes more effectively

and to achieve better results. In addition to providing an evaluation of the profitability of each programme, they support the strategic development of programme activities and the activities of Tekes in general.

Foreign evaluators have assessed many of the completed programmes. The main benefits lay in the close co-operation between research institutes and the industry, the widespread involvement of small and medium size companies, and the high level of international co-operation. Technology programmes have been criticised for being too technology-oriented and too fragmented, and not allowing room for unconventional approaches. (Tuomaala et al. 2001). Moreover, there are various initiatives and schemes that concern the establishment of framework conditions conducive to innovation at regional level, most notably the Centre of Expertise Programme. Part of the R&D funds channelled e.g. through the TE centres finance co-operative R&D projects. The EU's Structural Funds, in particular the objective 2 RTDI funds and measures, also play an important role since they are typically integrated into regional projects of domestic origin.

Initiatives to support innovation activities in SMEs

The SMEs are an important target group for most policy measures, not least for those aiming to strengthen research carried out by companies and co-operation in general. In a recent assessment of the additional appropriation for research, the international evaluation group set as a future priority the encouragement of SMEs operating in conventional sectors to take up new technology (Prihti et al. 2000).

In 1992, Tekes launched the Technology Clinic Initiative, which dealt with technology transfer to SMEs and aimed at enhancing the absorptive capacity of SMEs. The main purpose of this initiative was to promote the adaptation of specified technologies for problem solving in SMEs in order to introduce new technological

possibilities and raise their awareness of external R&D resources. In 2002, nine generic types of clinics were running.

SMEs and innovation policy

The promotion of innovative organisational and management practices in enterprises was taken into the Finnish government program in 1996. This resulted in *the Finnish National Workplace Development Programme (1996-99)* co-ordinated by the Ministry of Labour. The aim of the programme was to boost productivity and the quality of working life by furthering the full use and development of employee competencies and innovation in Finnish workplaces. The programme aimed to achieve this by developing human resources and helping the workforce reform their modes of operation. The new programme period covers the years 2000 to 2003.

The rationale for this initiative was the recognition that the development of organisational practices is an essential part of developing the national innovation system. In particular, the programme was established to help business enterprises better adapt to the ever-changing environment and therefore promote productivity and employment. The research-assisted development programme aims to:

- support workplace-initiated projects
- speed up initiatives at the level of the workplace
- boost the use of research in developing working life
- create and maintain co-operation networks to disseminate and build up knowledge and competence
- increase international information exchange

One of the key features of the National Workplace Development Programme is its focus on network collaboration. The programme strives to promote networking in labour administration internally, between the various projects of the programme,

and with the scientific communities both at national and international levels. The programme also strives to achieve close co-operation with the main bodies that fund research and workplace development in Finland, such as the Finnish Work Environment Fund, the European Social Fund, the Academy of Finland, and Tekes, the National Technology Agency.

The Ministry of Finance published a further review of Finland's competitiveness and its development requirements at the end of 2001. The document lists the main strengths and weaknesses of entrepreneurship in Finland. The general conditions are pro-entrepreneurship: public opinion favours entrepreneurship, and competition legislation as well as control mechanisms are working quite well. However, weaknesses are related to the low number of enterprises compared to other OECD countries. In addition, there is a low drive to expand activities among enterprises. Also, the results of the Global Entrepreneurship Monitor (GEM) report (Arenius & Autio 2001) show that, in terms of Total Entrepreneurial Activity, Finland ranks 15th among the 29 GEM 2001 countries. This means that Finland’s overall ranking has remained stable. The Finnish public attitude towards entrepreneurship is generally positive: people think there are many opportunities for creating new businesses and they believe they have the skills and competencies to start new businesses. However, the motivation to start new businesses is low among the population.

At the beginning of 2000, the Ministry of Trade and Industry launched *An Entrepreneurship Project,* which is included in the Government’s programme. It sets out to increase the establishment of new firms and increase the growth and competitiveness of existing enterprises. The Entrepreneurship Project is implemented in co-operation with various administrative sectors. Nine ministries as well as the

Association of Finnish Local and Regional Authorities participate in the project. The Employment and Economic Development Centres, entrepreneurs, organisations within the sector and other partners also play a key role. The Entrepreneurship Project examines the life cycle of a company from the entrepreneur's viewpoint. Measures are directed at those life cycle stages that are most critical in terms of the company's success. The project has been divided into the following five life-cycle stages: (1) well-functioning markets, (2) entrepreneurship as a rewarding career option, (3) becoming an entrepreneur, (4) the first critical years of the enterprise and (5) the growth and development of the enterprise.

Interview-based case studies with SMEs

Four cases of SMEs were studied in detail in order to offer insights into the phenomena. The cases represent the following types of SMEs: i) a university start-up company within a knowledge-intensive business ; ii) a governmental research institute start-up company within a knowledge-intensive business, iii) a company integrating new technology into traditional products and iv) a fast growth SME targeting international markets spun off from university research. The average duration of an interview was 1.5 hours. The following themes were examined: i) Company properties (e.g. origin of the company, business orientation, main products, ii) history of the company, iii) linkages with public research organisations, iv) protection of intellectual property and v) public and private support on innovation.

Case One – a university start-up company
Basics

Company One deals with a language software technology and is a spin off from the University of Helsinki, with around 10 employees. It is located in the capital area and

was founded in 1986. The company's business idea is to create products designed to enable language technology access to computer services. The company has a range of products from end-user tools such as electronic dictionaries and spellers to enterprise services including indexing and retrieval support. The proofing tools were chosen for inclusion in the Microsoft Office package for Finnish, Swedish, Norwegian, Danish and German. The company's language technology is now used in most of the desktop computers in those countries, illustrating their continuing dedication to providing the highest quality language software solutions. Software components developed at Company One have been in commercial use since 1986. Over half of the company's turnover is used on research and development.

History of the company

The company originates from a research idea developed by two professors at the University of Helsinki. Currently, these two professors and a lawyer own two thirds of the company and the company's employees own one third. From the time of its foundation, the company grew very fast and by the year 2001 it had 60 employees. In the late 1990s, the company ran into financial difficulties. One reason for these difficulties was the decline in the IT sector and another was weaknesses in management and strategic planning. The director who was interviewed analysed the reasons that led company to crisis point in the late 1990s as follows: *"since the mid 1990s, Microsoft was the most important buyer and user developer of our products. In the late 1990s, Microsoft unexpectedly reduced its orders, which put our Company in a difficult situation. Even though the company had developed several products, it had not been able to commercialise them."* Three mistakes in the Company's business strategy were identified. Firstly, the company was too reliant on just one client

(Microsoft). Secondly, on the one hand, it regarded new technology as sufficient for keeping the business running whilst on the other hand, it neglected investments to support the marketing of its new products. The company had no commercial partner that could take over the selling of the products. A third mistake was that the company had not implemented any systematic research and development strategy, but all innovation activities were run on an 'ad hoc' basis. The director commented that ignoring marketing activities is a typical fault of Finnish technology-based firms. High-technology is regarded as a competitive asset as such.

As a consequence of vulnerable business strategy and the decline in sales, turnover fell dramatically during 2001-2002 and 57 employees had to be made redundant. The current director was recruited in order to help turn the company around in 2002.

The future prospects of the company are currently uncertain. The new director, however, believes that speech recognition technology will have significant potential in the future. To survive, the company will have to pay more attention to marketing issues and long-term technology strategy. As the economic situation in Finland and Europe is still uncertain, Company One is to maintain its current position in the domestic market and has currently no intention of growing internationally.

Linkages with academia

The original idea for the business emerged from basic research in the field of philology. Two professors were working on several research projects with commercial potential. They founded a new company to develop the business ideas further. The business ideas were transferred to the company through copyrights. Also, one university researcher left the university and joined the company.

Since its foundation, the company has been co-operating with the University of Helsinki and with four other Finnish universities. A natural reason for this co-operation is the dependence on new skills and know-how in language technology and the fact the professors from the Univ. of Helsinki are the owners of the company. Co-operation has been mainly organised around Tekes projects. The director was somewhat sceptical about the commercial benefit of the Tekes projects. If anything, the joint projects with universities have provided a window on the technological development in the field. The company has also provided job opportunities for the students. From the commercial viewpoint, outsourcing technology development to a university student is regarded much more useful and cheaper than doing product development in the company.

IPR issues

The main end-users of language software products are universities and internet companies. The products have been protected through copyrights. The company protects its technology by using a key code when selling licences to the customers. The programme is valid until the date that has been stated in the contract of purchase. The key code does not give exclusive protection and can be easily infringed. However, it is unlikely that the main clients of the company – universities – would violate the contract.

The first two IPR were hold by the two university professors but transferred to the company. No new innovations or new IPR have been done but major improvements and development have been done on top of these two IPR. The director assesses that only a small share of the current technology is comprised of the IPR that were developed by the university professors. Still, the company and the inventors

have argued about the amount of compensation of the original IPR. The director blames the university partners for having an unrealistic view of the commercial value of their inventions. He says that an external evaluator should do the assessment of the value of the research results. An increasing interest of universities to keep the rights on research results and overpricing of the invention are regarded as factors that can hinder the willingness of the company to co-operate with universities in the future.

Formal IPRs are important to protect the technology but the director admits that property rights cannot take care of the company's interest completely. Compared to the formal protection of the technology, he finds secrecy to be a far more efficient method of securing the protection of innovations than formal methods.

Public and private support on innovation

Since the mid 1990s, the company has received research funding for several research projects from Tekes. Tekes funding has been targeted at product development. Thus, Tekes support has played a crucial role in the product development of the company. The director argues that new technologies could not have been developed without public support. He also thinks that future-oriented technology has been a key element in coping with competition. According to the interviewee, Tekes has functioned fairly well except that the payments have been sometimes late in coming. Another critical point is whether Tekes funding is too confined to the technological novelty of the products and marketing demands are not sufficiently considered in decision-making. The company has also applied for funding from Finnvera but received a negative decision. The director thinks that the roles of Tekes and Finnvera are currently blurred and are overlapping to some extent. It is also argued that Tekes' impact on networking is not as big as has generally assumed.

The current innovation system fulfils most of the company's needs. In particular, funding for research and product development is regarded as the bright side of the public policy. From the viewpoint of small company, the main problems are related to the commercialisation of products, market entry and internationalisation. The director argues that more public support should be allocated to the commercialising phase such as demonstration and developing prototypes.

The private venture capitalists are blamed for behaving too similarly, being too narrow-minded and incapable of doing independent risk investments. One of the requirements for obtaining private venture capital is to have a good commercial partner. The role of Sitra (The Finnish national Fund for R&D) is criticised for not having a specific or distinct "societal" role in the investment sector. It does not help companies in crisis. Lack of risk funding is thus considered as one barrier for the creation of new businesses.

Case Two – a governmental research institute start-up company

Basics

Case Two is a spin-off company from the Technical Research Centre of Finland founded in 2000 and employing two people. It develops scanning devices and software related to the Print-to-Internet technology. The company's business idea is based on combining separate devices, such as mice, text reading devices, barcode readers, LCD displays, and digital cameras, into a single product, Visimouse. As yet, the company has no production or turnover. Currently, the company's marketing focus is in Finland but in the long term the company will seek to have access to international markets.

History of the company

The company is a joint venture by three Finnish companies. At an early date, it appeared that two of the founding companies were not enthusiastic about investing further in the new company and therefore a manager from one of the founding companies bought the shares of the other two. Today, the manager of the one founding company and his wife own the company. Other owners are a venture capital company and two VTT researchers who developed the technology.

The company's Print-to-Internet technology is based on a development project which started at VTT in 1995. The first system was tried in five high schools in 1997. Teachers used the system to obtain additional information on lesson topics. The teachers found that the pen scanner was considerably more convenient than typing queries. The system was patented in 2000, and was developed further by making the handheld scanner more sophisticated and versatile.

The first product developed in co-operation with VTT was expected to enter the market by the end of 2002. The new technology allows the user of a printed product to get additional information on some aspect of its content from the Internet. The company's technology opens new horizons for product marketing specialists, since it offers a wealth of opportunities for interactive packages and interactive advertisements. Product catalogues displaying bar codes for each item, for example, could invite the consumer to scan for further information. After scanning, the information would be sent to the customer's PC or mobile screen, after which ordering and payment would be fast and easy and bring together the features of the printed word and the Internet.

At the time of the interview, the product was still in its development phase. The director relied heavily on the technology. He argued that the quality and

functionality of the product are preconditions for success in the market place. Marketing is also considered an important factor to the success of innovation. However, testing with end-users has not yet been done and the marketing process is still in its early phase. The company is seeking collaborative partners for marketing and selling but no final agreements have been signed. The production will be outsourced to a Finnish company. The company is very technology oriented in the sense that the focus of the managing processes is in the product development and the product will be not launch until the quality of the product is guaranteed.

Linkages with PROs

The technology and product have been developed in close co-operation with two VTT institutes. The development project has been funded by Tekes. The collaboration with VTT Institute-One (hardware) came to an early end due to conflicts of interest between researchers and the company. The company was unwilling to pay the substitution to the VTT institute and its researchers for the patents, which were transferred to the company. VTT Institute-One had sold their rights to Licentia, which is a private technology transfer company and when Licentia offered the property rights to the company, the agreement contained a clause stipulating that the company had to pay a certain sum of money to the inventors. The director of the company thought that this would amount to paying twice for the rights to the invention. Although the aim of Licentia is to promote the commercialisation of inventions coming from public research organisations, the director thought that the technology transfer company had caused more damage to the relation between VTT and the company than helped in the commercialising research. The conflict between the company and Licentia was later solved with the help of lawyers. There were other

reasons for conflicts of interest. VTT's researchers were willing to take part in the marketing whilst the director of the company regarded marketing as company's responsibility. The director also thought that the VTT researchers were overly keen on the invention and could not leave it in their own hands. He also doubted whether VTT staff had enough competence in marketing issues. Therefore, unsatisfactory personal relationship (bad personal chemistry) between the director of the company and researchers at VTT was mentioned as a major reason for conflict.

Collaboration with another VTT institute has run successfully. The director of the company stresses that the successful collaboration with VTT Institute-Two is based on mutual thrust and the competence of the researchers.

Collaboration with VTT has been essential to the company for three reasons. Firstly, the company was set up on the basis of an invention that came out of VTT. Secondly, VTT has contributed to the development of product and helped taking it into the marketing stage. Thirdly, co-operation with VTT has brought a good reputation to the company, and, among other things, has helped it obtain Tekes and private financial support for product development.

IPR issues

Two patents filed by VTT protect the company's product. Patents provide formal protection for some part of the product, but not for the whole product concept. In addition, two patents are pending. Recently, a patent filed by an American company that gives better protection to the whole product concept has emerged. It is likely that this patent will be contested by Company Two and the American company. Company B seems to be in difficult position because its competitor has filed the patent a month earlier. Thus, a new patent filed by the American company might be a

serious threat for the Company Two. The director argued that it might be helpful that the Finnish product was introduced on websites in 2001, and the publicity helps defend the patent against the American company. The situation described above raises questions as to whether the Finnish inventors made enough experimentation before making a patenting decision and completed the definition of the invention.

In general, the director was somewhat sceptical about patenting as a method of protection for new technology. He argues that patenting does not provide exclusive protection and patents can be easily infringed. Further, patenting is an expensive and difficult mean to obtain protection for a product, especially for a small company.

Public and private support on innovation

It was argued that Finland provides good ground for small technology companies. Finnish people are receptive about adopting new technologies and technological devices, which makes marketing more manageable. However, the scarcity of risk capital is regarded as a major weakness in the Finnish innovation system. Venture capitalists are blamed for imitating the others. Thus, the director considers public funding to be very important in encouraging entrepreneurship and business start-up.

Public support provided by Tekes and Finnvera has been critical to the company's existence and the development of its product. The director regarded Finnvera's decision-making as flexible and straightforward. In particular, the feedback during the application process had been useful to the company. Funding from Tekes has helped in securing funding from private venture capitalists. However, the decision-making by Tekes is criticised for being too slow and the payments were paid in arrears. The latter factor in particular has caused problems to a small company

that has little cash assets (cash in hands). A major gap in public support was said to be in the early development phase of small businesses.

Case three: A company integrating new technology into traditional products

Basics

Company Three is a research centre of wearable technology employing 17 people from various fields of science and technology. The company's business model is to develop new product concepts in the area of fashion to the global market. The company's turnover is still small, but it is expected to register profits in 2004. The main aim of the company is to carry out basic research on Smart Clothing technology and develop key components, develop Smart Clothing concepts and put together and consult a network of subcontractors. The concept of Smart Clothing is as follows: it refers to clothing with added intelligence, i.e. clothing that facilitates the wearer's actions or adds to his/her capabilities with the means of information technology, electrical equipment and telecommunications. Smart Clothing can also consist of "smart" fibre or textile solutions that react in ways not possible for conventional textiles, either with the help of the above mentioned equipment, by means of simple mechanics, or for example, biochemically.

The company's major business partners are global players such as Orange, Adidas, Nike and Lewis. These companies are vital to the Company because they have marketing capabilities and existing marketing channels. Collaboration with these global players provides Company Three with a remarkable growth potential. Its first product was released in December 2002 in partnership with Orange, which takes responsibility for marketing and advertising. Company Three co-operates with a large Finnish electronics company but the new product is kept secret. The interviewee

pointed out that it is necessary to focus business on internationalisation markets. Otherwise the company's life span risks being very short. A lack of skilled workers is seen as a major concern and barrier to growth. The company is located in a small town, which may be unattractive to young and skilled people.

History of the company

In 1997, a large time-honoured Finnish fashion company was sold to a Danish investor. At the time, it had become evident that, in order to cope with tighter global competition, major structural changes had to be carried out within the textile industry. The new owner urged that new business activities be initiated in order to develop the company to be more competitive globally. As a consequence, it founded a spin-off company that focused on the Smart Clothing concept.

The former CEO of a large Finnish fashion company played an important role in setting up the new company. The CEO made a personal equity investment in the company, which in turn attracted Sitra and employees to invest to in the company. Currently, the main owners of company are the Finnish Holding company (60 per cent), Sitra (a public venture capitalist, 30 per cent) and the staff of the company (10 pr cent). Tekes funding also played an important role in supporting the development of the first product.

The company operates in the global context. It utilises knowledge related to different technologies. Its main task is to develop new fashion concepts together with subcontractors. It does not aim to develop the technology itself, but integrate existing and new technology into its own product concepts. The whole business idea is to create smart and usable innovation. The first prototype was launched in 2000. It was an arctic survival garment that increases the wearer's possibilities to survive in case of

an emergency in arctic conditions. The development process of the first prototype was purely a research project.

Links with PROs

The company has strong collaboration contacts with universities. Its own resources and capacity to develop new technology is rather limited. The company has co-operation links with two Finnish universities. One of these provides technological expertise and the other has expertise in the area of arctic environment and design.

The first prototype was developed together with the two universities. The funding for the development of the product was gained from Tekes. The company's research director is very satisfied with the collaboration with the university partners. Contacts between researchers at the universities and the company are based on mutual trust. Collaborative teams have generated a number of new concepts and some of the ideas have been taken to the product development phase. The university has also been an important recruitment channel for the company: almost all new employees of the company have been recruited through the collaborative projects. It is also noted that university researchers have published research results concerning Smart Clothing technology that have brought visibility to the new products as well as the company itself. Potential disagreements about publishing the research results have been prevented by signing an agreement at the beginning of the projects.

IPR issues

The company uses both informal and formal methods to protect its products. Patent applications are filed as soon as possible once a new invention has been made.

Instead of seeking protection for new technology, the company aims to protect its product concepts.

In general, formal protection of the intellectual property is considered necessary because the company functions in the global market. Patents are cited as a key element to ensure that global partners are interested in a partnership with Company Three. A famous brand name is said to give protection to the products but it does not provide such a good protection as do patents. Despite the research manager's trust for the protection provided by patents, new ideas have to be developed continuously because older concepts can easily be copied and patents can be twined. Thus, proper timing and fast development are also factors that can give the company a competitive edge.

The company has not had any conflicts with universities on IPR issues. The company has paid small substitutions to the university researchers for their inventions. University researchers have been more enthusiastic about helping the company be successful than earning some extra money from their inventions.

Public and private support on innovation

Tekes' role has been essential to the creation of the company. Tekes has provided financial support for the development of the first prototype in the early stage, which finally led to the creation of a new business. Secondly, Tekes funding also attracted follow-on investments from Sitra and a private individual investor (business angel). Thirdly, Tekes has provided technology consulting assistance, which is considered important especially for a start-up company. The interviewed manager is satisfied with the Tekes' decision-making procedure and regards staff as competent.

The company has obtained funding from Finnvera, but the enforcement of the decision has been postponed due to lack of money. The Finnvera services are fiscal aid to the technology development. The interviewed manager has doubts as to whether Finnvera has competence in business consulting.

Case Four: A fast growth SME targeting international markets

Basics

Case Four is a joint venture by two Finnish companies and has a staff of 18. It designs, manufactures and markets rare-earth doped speciality optical fibres for optical communications and photonics application. The products are designed to enhance the performance and lower costs in optical networks. The company's turnover is about 2 million euros. The company is located in a rural community, approximately one hour from a metropolitan area. All of its production is exported and about 10 per cent of turnover is used for research and development.

History of the company

Two Finnish companies established Company Four in 1999. At the time, the general understanding among founders was that new technology would provide significant cost-efficiency advantages and much larger business opportunities than the existing companies had. Therefore, a new company was founded to commercialise new technology. Soon after the foundation of the company, Finnish venture capitalists became interested in making an equity investment in the company. Tekes funding was also secured for product development. The production facilities were commissioned and taken into production in early 2001. Today, the main owners of

the company are the two Finnish companies (80 per cent), researchers who developed the technology (15 per cent) and a private venture capitalist (5 per cent).

The development of Company's technology and intellectual capital can be traced back to the early 1990s. The interviewee describes the early phase of development of the technology as follows: "*We were an unorthodox research group. I moved from Nokia to the University of Art and Design and formed a new laboratory in the field of ceramics and glass research. Because we did not have enough expertise in technology, we started up a project with the Tampere University of Technology in order to combine know-how in high temperature technology and aerosol physics. Collaboration between two research groups resulted in the new technology, which was a hybrid technology . The first patent was filed by this group. At the time, we asked universities' administration whether they were interested in patenting our invention but they had no money. Then we applied for support from the Foundation for Inventions, which replied in the affirmative. The first patent was filed in 1995 and accepted in 1998. "*

The company's technology is the culmination of research and development in universities and research institutes that excel in quantum physics, glass processing and optical waveguides. In the DND method, the glass is doped in situ with the soot particle nucleation. This ensures that the glass particles have a homogeneous composition before the next successive processing phases. The company's process is the first truly new perform deposition method since the 1970s. Increasing optical complexity leads to increased component losses and thus creates demand on boosting the power levels at low cost. The high erbium concentration reduces the required fibre length in amplifiers and offers cost savings.

In 2003, the company is expected to break even and generate a profit. The burst of the “bubble” in the software sector in the early 21st century has slowed down the growth of the company. An interviewed manager argues, however, that the decline in the economy has brought some advantages: the company has been developed step by step and the slowdown has given time to make new initiatives considerately. He spoke of a competitor who started at almost the same time as Company Four and hired new staff aggressively, employing 1000 people in a short period. Due to the decline in market demand, the competitor had to cut 80 per cent of its staff in the early 2000.

Company Four is strongly oriented towards international markets. The research director estimates that the company is the third largest company in its field and is rapidly reaching the first place. The future outlook is promising and in 2005 the company is expected to be a market leader in its field.

Linkages with PROs

Collaboration with universities has been running smoothly. About 20 university researchers are currently involved in research projects with Company. Tekes and the Academy of Finland fund most of the projects. Many university researchers have themselves applied for funding for research. Taking the case of Finland, most Finnish researchers and experts in the field are familiar with each other: "*Most of the company's workers are "pals" with some university professors"*. Another element in the relationship between Finnish companies and universities is adequate funding to universities and research: "*The government regard research as important"*. Research as a profession is respected in the population and this is one reason why high-intellect people stay on at universities.

The company has taken advantage of the availability of Tekes and other public funding as much as possible. Tekes funding is used mainly in long-term projects while the company commissions short-term projects on a contract research basis. The links with university staff are very close. The employees of the company have participated in a number of scientific conferences together with university researchers. After international conferences, the company has organised workshops to discuss the latest development in its field.

IPR issues

The interviewed director feels that patents are important to their management and competitiveness but at the same time he is sceptical about their exclusiveness. He thinks that human resources are a far more valuable competitive asset for the company than the legal protection of technology. In the founding phase, the company had an aggressive recruitment policy. It scanned all skilled researchers in the field and persuaded them to work for the company. One fourth of the personnel currently has doctoral background. To increase the attractiveness of the company as a working place, it offers employees the opportunity to share in its ownership. It has also uses an option system, which provides additional rewards for employees.

The company's patenting strategy is to keep its patents "hidden" as long as possible by avoiding to move to the international phase in patenting. The reason for this is that they have no illusion about being able to defend their patents against potential infringement by American firms. The exchange value of patents is also mentioned a reason for patenting. The interviewed director assumes that small companies will be consolidated in the future and the value of IPR will be highest in the negotiation phase. Thus, the patents are important when evaluating the market

value of the company. Especially in the IT sector, patents have an intrinsic value that ensures that the company is taken seriously. The interviewee stresses that "*without having legally protected technology, the company has no value in the long term."*

So far, the company has not had any problems with the distribution of IPR with its university partners. In every research project, the rights have been defined in advance. The director finds that IPR issues are getting more difficult as universities become more interested in economic benefits. He assumes that companies will have to pay more royalties to universities in the future. He believes that start-up companies may suffer from the change in IPR legislation more than existing companies.

The company uses private patenting offices to file new patents and scan patents made elsewhere. An interviewed director had a high opinion of Finnish patenting offices and held them to be very competent. The American patenting activities are followed actively in the company. Through the scanning of patent information, the company can receive topical information on the developments in the market.

Public and private support on innovation

Conversation about the future development reveals that the current decline in the growth of the IT sector is likely to slow the company's growth in the near future. However, the interviewed director is fairly confident about the success of the company. There are, however, some concerns related to the Finnish innovation environment. The interviewee is concerned about the adequacy of highly educated staff in Finland. There are two main reasons why doctors are needed. Firstly, qualified staff is necessary to keep to the cutting edge of technology. Secondly, most representatives of clients are doctors themselves and it is important that Finnish

company employees who negotiate with clients have a similar educational background. The major bottleneck affecting the development of small and medium size companies is too narrow a technological know-how*: "If we choose too scanty a technology focus, we are going to be strangled by our own excellence ... new innovations are still emerging but they are not significant enough."* The interviewee points out that entrepreneurship is not appreciated in Finland among academics. If an entrepreneur goes bankrupt, he is deemed to be a loser and cannot obtain public entrepreneurial loans anymore. In America, for instance, the national attitude toward failure is more positive and it is thought that people can learn a lot from failures.

Conclusions and Policy Implications

This chapter has shed light on the institutional, regulative and cultural (=attitude) factors influencing the commercial exploitation of research and the capacity of SMEs to absorb new technologies with respect to Finland. The paper is based upon empirical findings in the literature, policy documents and four illustrative case studies of Finnish start-ups. The paper consists of an exploration of the Finnish industrial structure and the role of SMEs in innovation. It goes on to analyse the public implementation infrastructure used to promote commercialisation of research. Finally, it ends with a section on the summary and policy implication of its findings.

The Finnish innovation environment

As measured by various S&T indicators, Finland is performing well in innovation and R&D, but there remains room for the improvement of national performance in commercialising technology and the knowledge produced in public research organisations. Some of the major strengths of the Finnish innovation system are the

high investment in R&D, high share of the population with tertiary degree, high rate of patenting and close networking between research and industrial communities. Since the early 1990s, Finland's innovation policy has placed emphasis on cluster/network development. A key objective of the network activities is to increase connections between enterprises and research organisations. A cluster approach has resulted in a shift from policies based on subsidising and protecting industries to a focus on the framework conditions necessary to cluster development. Hence, the analysis of the governance of innovation and public initiatives for the commercialisation of research would seem to point to the catalysing role as being the primary objective of government and public R&D organisations. This role would emphasise the technology transfer and technology dissemination effects of public sector performers to the private sector.

Another element of the Finnish approach is that the development of innovation environments has wide political support in Finland. The Finnish innovation support system involves many agencies and initiatives aimed at supporting networking, commercialisation of research, technology transfer and SMEs. Over the years, the support system has, however, become rather fragmented, although there has been an emphasis on one-stop-shop types of services (e.g. EEDCs). Access to support programmes is not a problem, but overlap between programmes and bureaucracy, and between public and private, may be problematic at times. In addition, a lack of co-ordination may expose the support system for financial misconduct. It has been criticised that operations that are under the government's responsibility do not fully meet the requirements of the rapid development in the private sector. Critical areas include innovation financing, the utilisation of knowledge and know-how in business companies as well as elsewhere in society and the entrepreneurial culture and

motivation amongst the population in general. Finland has too few financial incentives for entrepreneurial activities and taxation is considered too backbreaking. The taxation problem particularly concerns new firms.

According to the results of four illustrative interview-based studies with SME, services for the commercialisation and marketing of technologies were regarded as underdeveloped. Furthermore, technological competence in public supportive agencies (e.g. Tekes) was regarded as high but business competence was questioned.

SMEs and innovation

The analysis of policies for supporting SMEs and their innovation capabilities indicate that there exist at least three critical areas for innovation by SMEs: lack of financial resources, limited R&D capabilities and limited access to new knowledge and technology. In general, financial markets are regarded as functioning well, but young, small, growth-oriented, R&D intensive, and high-technology firms face problems in obtaining finance. This means that potentially innovative SMEs cannot fully realise their growth potential. Despite the fact that the venture capital industry in Finland has expanded considerably, its competence has also been called into question. In addition, it is blamed for having a low inclination towards risk-taking. From this perspective, public support for commercialising technology would be a welcome development. It can also be argued that Finnish technology policy has been technology-driven in the sense that the policy instruments and major volume of financial public support targeted at the small and medium-size enterprises have mainly promoted networking and the early phase of innovation (research and development). Companies desire more financial support for commercialising technology and assisting firms in products market entry.

Another crucial demand for SMEs if they are to benefit from a global economy is access to, and their capacity to utilise, new technologies. The issue of education and training is crucial, not only for the promotion of innovation, but also more generally, for providing a competitive foundation for SMEs. Because SMEs often lack the resources to engage in in-house R&D, public support for basic education, for financial assistance with SME training, and for promoting networking with public research organisations is needed.

One of the growing influences on the environment in which SMEs are operating is internationalisation. In an international context, an important potential role for the government is to help SMEs gain greater access to international markets, technology, know-how and finance, in order to facilitate their growth and allow them to better withstand increasing competitive pressures for which small firms may not be well prepared.

Universities and the commercialisation of research

The quest for the increased impact of university research in society, tightening of industrial relations and faster commercialisation of research findings are encouraged strongly by the government. The pending revision of university law and law of invention are concrete measures to promote these objectives. The general attitude towards clarifying regulations and practices concerning IPR activities remains positive amongst researchers and university administration. However, there are some doubts about the need for revision of university law. There are also critical views about the economic benefits of commercial activities in universities. Building up an infrastructure for commercial activities at universities is costly and the economic revenues from commercial activities still remain uncertain. The debate on the

potential negative influences of commercial activities carried out by universities on their basic tasks such as education and research has been minor in Finland.

In addition to the reformation of the regulatory framework for universities' entrepreneurial framework conditions, we came across observations for other improvements. Cultural aspects and entrepreneurial education are to be considered if they are aimed at nurturing the commercialisation of research at universities and other public research organisations. By cultural aspects, we mean the personal willingness of researchers to take part in the commercialisation of research and encouraging an environment for the commercial utilisation of research in general. Evidently, researchers need incentives to put their time and attention to new tasks. The differing motivations toward entrepreneurial activities may vary across disciplines, faculties and even universities. One of the key bottlenecks in Finland is a lack of competence in the protection of intellectual property and technology management within the Finnish universities and public research organisations. Other identified bottlenecks in promoting the commercialisation of research and promoting university start-ups are: lack of risk financing to develop results to more mature stages, lack of incentives for researchers to play a role at the early stages of the commercialisation process and high threshold to move from academic career to entrepreneur.

Despite the central topic of policy interest in technology transfer from research organisations or university to the industry, little quantitative and qualitative information about the creating of spin-offs and commercialisation of academic research is available in Finland. More research on university patenting and licensing as well as institutional strategies and collaborative linkages are evidently needed to better monitor practices and deficiencies in the commercialisation of research.

Policy Implications

The findings of the analysis above will shed light on a number of issues being considered by policy makers. The following three aspects need to receive more policy attention:

1. More policy emphasis on innovation, user aspects and the entire chain of innovation from R&D to assisting product market entry.

The emphasis of the Finnish policy system has been strongly technology-driven in the sense that it has supported existing areas of technology, quality of research and knowledge capabilities of individuals. The current system should be developed to better respond to business needs and to take the user perspective into account. This means that increased attention should be paid to the stage of prototyping and demonstration and assisting products market entry. In addition, it has been recognised that any public policy that wants to stimulate commercialisation of research should bear in mind that not only technological but also business knowledge should be developed to support the commercialisation of research. Therefore business-coaching activities such as business plan development, start-up coaching and specialised advice and consulting should be included in the repertoire of public supporting schemes.

2. Selective public support for SMEs

The basic rationale of R&D policy is that enterprises, and certainly SMEs, under-invest in R&D because they would never be able to fully capture the benefits of their efforts. The government should intervene and correct this market imperfection by

making available financial incentives in the form of fiscal or R&D grants. Many potentially innovative SMEs do not invest in R&D because they are able to increase their competitive advantage significantly by adopting a standard technical solution that has already been developed. In addition, technology start-ups appear to be very different, both in their business models and needs. Technology start-ups (and especially those attempting to international markets) often face an equity shortage in their starting phase while SMEs in traditional branches (e.g. clothing, foodstuff, ship-building industries) are associated with a lack of technological capabilities. Thus, more targeted aid should to be channelled to the different types of SMEs. SMEs in traditional fields particularly need aid to increase their innovation capabilities and familiarise SMEs with the use of third party expert advice: while financial support, to overcome the barriers of internationalisation, is relevant for high-tech SMEs. This stresses the importance of emphasising the selectivity in the allocation of government support to SMEs. This also provides a new rationale for government involvement in investments.

3. The system should focus far more on entrepreneurship and on the promotion of entrepreneurs.

As documented in this report and elsewhere (see e.g. Ministry of Trade and Industry 2003), the atmosphere in Finland does not encourage academic entrepreneurship or other entrepreneurial activities. Thus, there is a general need to encourage university researchers to take up self-employment and spin-off university activities. In the light of the current economic situation, there is a need to increase the mobility of workers between public R&D organisations and companies. Furthermore, there is a need to

increase competencies in intellectual property and technology management both among SMEs and research organisations. Especially in research organisations, there have not been enough resources for the marketing of research activities. There is also room for improvement in co-operation between different actors which are enhancing commercial activities in R&D. Promoting the development of secure and transferable property rights, and the associated administrative processes, registers and institutions will be key measures in the future.

The challenges discussed in this report call for a more holistic approach to the system of innovation. Any effective policy to encourage the commercialisation of research will need to integrate different public initiatives and different networks of actors. At the very beginning, the ministries responsible for innovation activities and the utilisation of research have to take actions to encourage and facilitate the development of mutually beneficial co-operative arrangements appropriate to the needs of participating firms and research organisations. In this respect, these policies will need to be selectively targeted at firms that are seeking either to enter or increase their know-how and competitiveness, but lack the internal resources to achieve this independently.

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Chapter 5: Country Report, Sweden

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Introduction

A perusal of the policies for public funding of research and development (R&D from this point on) among OECD countries will reveal a convergence on the broad policy objective of creating a knowledge society. This emphasis on the knowledge society creates the need for policymakers to stimulate those processes and institutions that can contribute to increasing the rate of innovation in their respective societies. Over the last ten years, a fairly standardized package of policy instruments for promoting innovation has emerged and two key components of this package are: (i) promoting the commercialization of university based research and to some extent education and (ii) promoting the growth and development of small and medium sized enterprises.

In many respects, the logic behind the two policy initiatives is similar and rests on interdependent arguments. For instance, the argument for promoting more collaboration between the university and industrial sectors is that the pace of technological change and the increased dependence of economic activity on knowledge suggest that firms need to be directly connected to knowledge producing organizations in order to be able to maintain competitive advantage. Likewise, the argument for focusing on stimulating SMEs is that increasingly the structure of modern economies is transforming in such a way that it is small agile firms that can keep pace rather than the large structures that are now dominant forces. Further it is argued that the commercialization of emerging technologies and services depends on the existence of a vibrant SME community. The SME is therefore seen as the

preferred structure for commercialization of the knowledge produced in universities and public research organizations.

The purpose of this chapter is to provide a brief overview of the policy mechanisms devised and implemented to achieve this end. Innovation policy is a multi faceted area and even if one restricts oneself to that part of innovation policy which is focused on SMEs, it is still a large area. In this document, our focus will be on one aspect of the policy towards SMEs and this is that which is concerned with the commercialization of academic research and more specifically how this impinges on SMEs. In order to explicate this, we will examine policy for the commercialization of research and policy for revitalizing and promoting the SME sector. In particular we will look at collaboration between public research organizations and SMEs. The chapter will therefore focus on the general question of 'what are the specific regulatory, institutional, and cultural (=attitude) factors that affect commercialization of academic research and university-industry interaction?'

The document is divided into four main sections and a number of appendices. The present section outlines the purpose of the report, provides some background data on Sweden such as population size, structure of the economy and other general data on the policy context for orientation purposes. Section 2 outlines the industrial structure and the role of SMEs in that structure. This is followed by a third section which is a description of the nature and structure of the public R&D sector mechanisms, institutional and regulatory that have been introduced in order to promote the commercialisation of academic research in general. Section four provides an overview of the mechanisms that are specifically aimed at university-SME interaction, an analysis of how they function and four illustrative case stories to

provide a more detailed picture of SME-university collaboration. The final section outlines a number of policy implications of the foregoing.

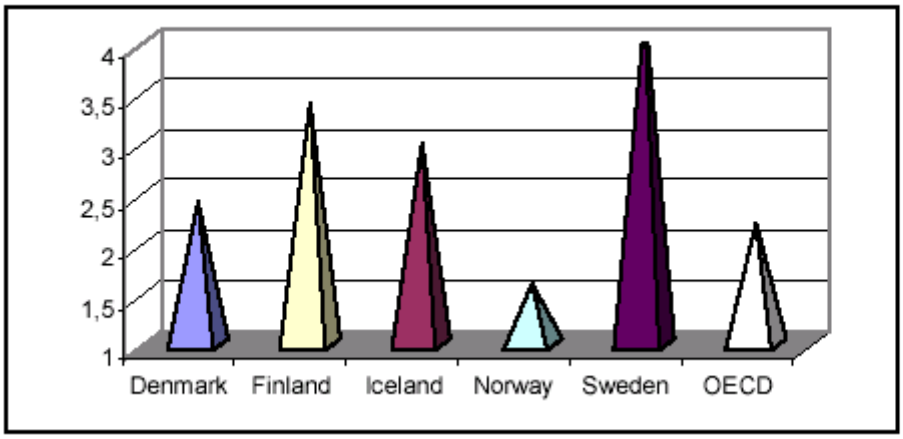
The policy context

The term innovation policy is rather new to the Swedish policy context (first introduced in the 1990s) and the different elements that are recognised as part of innovation policy such as research policy, policy for promoting SMEs and other parts of the business sector have not been treated or administered as part of a coherent initiative. In fact, one of the more perplexing problems for students and practitioners of innovation policy in Sweden is that there is no complete up to date overview of the area. In appendix 1, we have attached a figure which provides the closest that we could get of an overview of the organisations in the Swedish innovation system which was provided to us the Swedish agency for Innovation Systems. This figure should be seen as a starting point for understanding the system rather than a complete overview. One of the contributing factors to the incompleteness of information in this regard is that the system is in flux and has been so since the early 1990s as a result of a radical process of reorganisation which has been and still is in progress.

Sweden has a population of ca 9 million inhabitants and an unemployment rate of 4,2%. Like many other OECD countries Sweden experienced an economic crisis in the early 1990s. The government response to this was deregulation of markets, privatisation of public companies, increased public investments in strategic research and support to commercialisation of research and technology transfer to SMEs. According to OECD, Sweden has the largest expenditure in relation to Gross National Product (3.8%) of all OECD countries and among the Nordic countries, only Finland has a comparable level of investment in R&D (see figure 5.1)

Figure 5.1:

Gross Domestic Expenditure on R&D (GERD) as percentage of GDP, 2001



Source: OECD

below for further information). More than 70% of this is corporate R&D concentrated in large firms and there is a high probability that development work accounts for a significant portion of this figure.

The patent system

Sweden is in the forefront with most the European patents per million inhabitants in 1999, and in third place, only behind USA and Japan in number of American patents the same year (Andersson et al., 2002, p. 12). Thus, Sweden positions itself well when it comes to R&D production measured in patents. Contemporary Swedish law allows researchers at universities to keep ownership of patents (a.k.a. the professors' exception), which is an exemption from the general regulation on patents developed by employees. The beginning of the 1990s saw the initiation of a heated discussion about whether the rule on professors' exception was an obstacle to more effective commercialisation of academic research. The issue of patent ownership in higher education institutions was raised again in the government research bill of September 2000 (Prop. 2000/01:3).

The case for passing ownership rights to higher education institutions is based on the argument that this would give universities an incentive to become more active in promoting commercialisation of research results, and that universities as organisations are better equipped than individual researchers to look after IPR. However, there are those who maintain that universities themselves do not have any strong incentives to promote and facilitate technology transfer to the commercial sector. In fact, Henrekson (2002, p.6) argues that it is in the interest of the universities not to promote such contacts, because of difficulties to keep attractive personnel due to relatively low remuneration at universities in relation to the corporate sector. Another option would be to promote some general mobility between academe and the corporate sector. This is however still problematic in the Swedish university system. Further, there are no legal barriers to universities making agreements with their staff on intellectual property rights but so far the incentives to do so have been relatively few. In fact, Swedish universities commercialisation activities are governed by a general legislative arrangement which is known as the Third Task or mission. Although it has been understood that universities and university colleges in Sweden would see it as part of their mission to disseminate the results of their knowledge production to the rest of society, it was only in 1997 that this was formalised into a law. The Third task is however not specifically about commercialisation of research results but dissemination of all kinds. Commercialisation activities are however promoted under the rubric of the Third mission. The extent of commercialisation of research results is moreover also a question of research cultures and traditions. So the question is whether the legal issue really matters, or whether it is the lack of incentives and initiatives on behalf of the universities that should be the focus.

Recently the debate on the professors' exception has been showing signs of reaching closure. In response to a request from the government, the Swedish Agency for Innovation Systems (VINNOVA) has put forward a proposition. This proposition recommends that the professors' exception rule should be upheld and that the government should provide resources to universities to give them the possibility to offer support to researchers who are interested in commercialising their research. Although this proposition was introduced just before the summer period and it is likely that not many people are yet aware of its existence, a cursory examination of the publications which feature debates on this type of issue as well as national newspapers suggests that the research community is not against this proposition. In the light of the changes made in Norway and Denmark in this respect, the Swedish approach may appear to be a rather timid step. It may however be that this approach is the most pragmatic given a number of extenuating circumstances including the fact that patenting is a very costly affair and the jury is still out as to whether the benefits for universities outweigh the costs. A second factor is the institutional structure in Sweden which makes for a marked difference in the realpolitik of the situation. Further, as the Vinnova proposition rightly points out a number of auxiliary measures such as supporting increased mobility between the university and industrial sector as well as promoting the development of a Nordic initiative for patent insurance at the European level are equally important focusing issues for policy intervention in this area.

Structure of the Industrial Sector in Sweden

The industrial sector in Sweden is dominated by large established companies many of which are multinational. There is generally a shortage of medium sized firms and rapidly expanding small companies. Moreover, of the middle-sized companies with a

significant proportion of academics, own research and development department, and exports of at least 50%, a very high degree are tied to larger industrial groups (NUTEK, p.47). This is illustrated by the fact that the 20 largest companies account for 65 % of the business sector. Within the manufacturing industry, the 20 biggest companies accounted for about 74% of R&D expenditures, which is an increase compared to 1997. Within the manufacturing industry as much as 81% of R&D activity is performed within companies of at least 1000 employees (SCBa). Sweden like other OECD countries has since 1990 been overhauling its research policy with the intention of promoting increased interaction between universities and industry and ultimately the creation and development of SMEs. This policy initiative has as one of its ambitions, the revitalisation of the existing SME sector.

Structure of the SME sector

More than 99% of all enterprises within manufacturing, construction and services in Sweden are classified as SMEs, i.e. they have fewer than 250 employees. The majority of enterprises (97%) have up to 19 employees while about 1.7% have between 20 and 49 employees. Only 0.5% of firms have more than 100 employees and approximately 0.1% have more than 500 employees. In total, three out of five employees in the private sector were employed in SMEs in 2000. Approximately 42% of employment was located in firms having fewer than 50 employees. Within manufacturing (SNI 15-37), approximately 24% of employment was found in firms with fewer than 50 employees while those with fewer than 250 employees accounted for approximately 46% of the total. The importance of the SME sector is also reflected in its contribution to the economy. In terms of production value, the SME sector accounts for approximately 55% of the total production value, while firms with

fewer than 50 employees generated over one-third of the production value. The SME contribution to GDP in the Swedish economy is 57%. When it comes to investments, the SME sector accounted for 68% of net investments in 2000 (SCBc). The SME sector in Sweden is therefore of major importance both in terms of employment and economic contribution.

As mentioned earlier, the transformation of the Swedish innovation system with respect to the commercialisation of knowledge from universities and university colleges is quite extensive. Although there has been considerable emphasis on the promotion and development of SMEs, this has been done as a special task integrated in the general innovation policy. In this section we will focus on these measures but it is important to bear in mind that many of the more generalised measures outlined earlier are in principle available to SMEs and as far as we have been able to ascertain, there are no structural or informal obstacles to SMEs availing themselves of these measures

One of the consequences of a more general move towards focusing on innovation as a macro systemic goal has been a change in the nature and focus of the policies aimed at SMEs. A general description of this shift would be to characterise it as a move from selective, delimited policy measures to a more general and horizontal policy approach. There is more emphasis on the development and promotion of institutional preconditions for SMEs and an integration of SME policy in what may generally be described as entrepreneurship policy. It is still too early to state with any confidence what will be the impact of a change of focus to entrepreneurship rather than on SMEs at the policy level since many of the measures are fairly recent (circa two years). The general guiding principles on which the policy for small firms rests are:

a. Strengthening Sweden's industrial and international competitiveness by promoting good conditions for growth and renewal. This includes a consistent competition policy, easy access to competence capital (information and advice)
b. Improving the legislative and regulative framework
c. Good access to finance and facilities for stimulating entrepreneurship (see section on finance below)
d. Special measures for targeting disadvantaged groups e.g. women, minorities, youth
e. Promotion of networks and clusters

The public R&D system in Sweden

The public R&D sector in Sweden is distinguished from that of other Nordic countries by its size and nature. A second peculiarity of the Swedish public R&D sector in relation to that of other Nordic or even OECD countries is that the majority of publicly financed R&D is conducted within the university and consequently the public institute sector is relatively small. For this reason the part of this report which focuses on the Swedish case will use the term university for the most part rather than public research organisation. It may be argued that the view that university research should be of use to the wider society is not at all new to Sweden. The 1970s was the first time this particular view on university research was outlined and became a part of the national research policy with the introduction of the sector research policy doctrine. At this point, a number of mechanisms were introduced to promote the transfer of knowledge from universities to the wider society. These mechanisms are listed in list 1 below. Although the emphasis was on knowledge transfer rather than

commercialisation and on the public sector for the most part as opposed to industry, one may see these as the first generation of instruments of collaboration. It should also be noted that many of these mechanisms are still in effect today and although they are not aimed at SMEs in particular, many of them can be used by SMEs.

List 5.1: First generation mechanisms for knowledge transfer

Contact secretary

The contact secretariat was introduced by the former Board for Technical Development (STU) which set aside funding in the late 1960s for the employment of contact secretaries at technical universities initially. Later this was extended to all universities and university colleges. The purpose of the contact secretary was to first and foremost help smaller companies to gain access to universities and university colleges. The actual content of the contact secretary's job varied from university to university and the initial focus on smaller companies was widened to include larger firms. The duties of the contact secretary were also expanded to include assisting university researchers to take out patents, start companies, etc. The responsibility for the contact secretariat was passed on in the 1980s to Universitets-och högskoleambetet.

Contact researcher

Since the 1970s universities and university colleges have financed 'contact researchers.' This means that a researcher who is hired at a university or university college may during a specified period of time work either part or full time with a company or another organization. Money from the state may be used to fund at least half of the salary costs. The nature of the researcher's assignment while s/he is on secondment should be to participate in research around a specific problem. One of the

main purposes of secondment is that it would lead to a wider network and in the long term new research commissions for the university or the university college. The participating researchers get an opportunity to experience of the conditions for research and development work outside the university or university college. In the initial stages, there was a special fund for this type of activity although it was very small. This has been changed and now it is up to the higher education institution to decide what resources it will set aside for this.

Adjunct professors and industrial doctoral students

This is a form of U-I interaction that was also introduced in the mid 1970s and is built on direct personnel exchange between industry and the higher education sector and the basis is employment outside universities or university colleges. Adjunct professors were also introduced in the mid 70s and the holder of this position should be competent to be a professor and will be hired part time at the university. The position is usually time limited (normally about 3 years in the first instance with the possibility of an extension of a further 3 years). The number of adjunct professors has grown steadily particularly in the technical areas. The adjunct professorship provides the higher education sector with access to highly qualified lecturers and supervisors who have their main employment in industry. The institution of higher education usually pays for the cost of the work time spent at the university. There are also contracts in which the company pays for this time as well.

Industrial doctoral students

Industrial doctoral students are doctoral students who are corporate employees who have within their employment contract provisions that enable them to pursue doctoral studies at the university.

Science Parks

The first science park was Ideon in Lund (1983), after which a number of science parks were established at other universities and university colleges. The purpose of the science park was to offer a good working environment for R&D intensive firms. There are two main types of activity that can be found in science parks: (i) R&D departments of large firms for the purposes of networking and recruitment and (ii) spin-outs from the university or university college. Initially science parks were limited to providing physical facilities (offices and practical service); later the functions of science parks were expanded to include support for patent application, venture capital, etc.

In recent years the number of science or (teknikparker) parks has burgeoned to 30 and have been organized in an umbrella outfit known as Swedepark. As of last year (2002) they boasted a membership of 30 science parks and circa 1700 firms with about 50 000 employees.

Industrial research institutes

The industrial research institutes are probably the oldest of the mechanisms introduced to promote U-I collaboration and the first such institute was introduced in the 1940s. There are about 30 industrial research institutes (see www.iris.se for information on all the institutes) and many of them have a broad mandate e.g. (environment, optics, corrosion). The main task of the industrial research institutes are:

- Industry related research
- Innovations and problem solving
- Technology transfer

- Collaboration and coordination of larger research programs with higher education institutions, industrial research institutes and industry as partners
- Contacts with foreign firms, institutes and other knowledge centres
- Development of new standards
- Assisting with the recruitment of research trained people to industry

Transformation of the Public R&D System

A concern that the research funding sector was all too fragmented, the onset of an economic downturn, the election of a conservative government to power in Sweden and preparations for Sweden's entry into the European Union all coincided to bring about a shift in policy doctrine. Sweden began to slowly outline a new science policy direction in the early 1990s (Ruin, 1991; Odén, 1991). The first significant act in this was the creation of a number of strategic research foundations with funding that was not tied to annual budget allocations but based on stock market earnings from an initial capital outlay. The creation of the wage earner foundations as they are called was a controversial moment in the history of Swedish science policy for several reasons (see table 5.1 below for an overview of the different wage earner foundations). The most important from the point of view of this document was the fact that all these foundations were all oriented towards funding research of a strategic cut that had hitherto not been common in Sweden. The main characteristics of the funding policy of these foundations include:

Table 5.1: Wage earner Foundations and their budgets

Name of Foundation & Purpose	Budget (billions SEK)
Stiftelsen för miljöstrategisk forskning - MISTRA www.mistra-research.se Funds strategic environmental research	3,9
Stiftelsen för forskning inom områden med anknytning till Östersjöregionen och Östeuropa Östersjöstiftelsen Finances research on Baltic countries conducted at Södertorn University College	2,5
Stiftelsen för vård- och allergiforskning - Vårdalstiftelsen	0,7
Stiftelsen för internationella institutet för industriell miljöekonomi vis Lunds universitet	0,3
Stiftelsen för internationalisering av högre utbildning och forskning - STINT www.stint.se Funds researcher mobility- Inviting foreign researchers to Sweden as well as funding research visits by Swedish researchers to other countries	1,6
• Stiftelsen för kunskaps- och kompetensutveckling – KK Supports the use of information technology; funding research at middle size universities and colleges and supporting exchange of knowledge and competence between industry and public R&D institutions	3,6
Stiftelsen för strategisk forskning - SSF www.stratresearch.se Funds research in medicine and the natural and technical sciences mainly	6,0

- Has several programmes which are aimed specifically at linking SMEs and regional universities and university colleges

  i. A preference for program funding and large grants spread over a substantial period of time (usually 4 years at a time with the possibility of renewal);

  ii. Emphasis on collaboration across universities and between universities and industry or public sector organisations;

  iii. Evaluation of eligibility for funding and evaluation of outcome of the programme in terms of scientific quality and relevance with the latter being given equal weighting as the former;

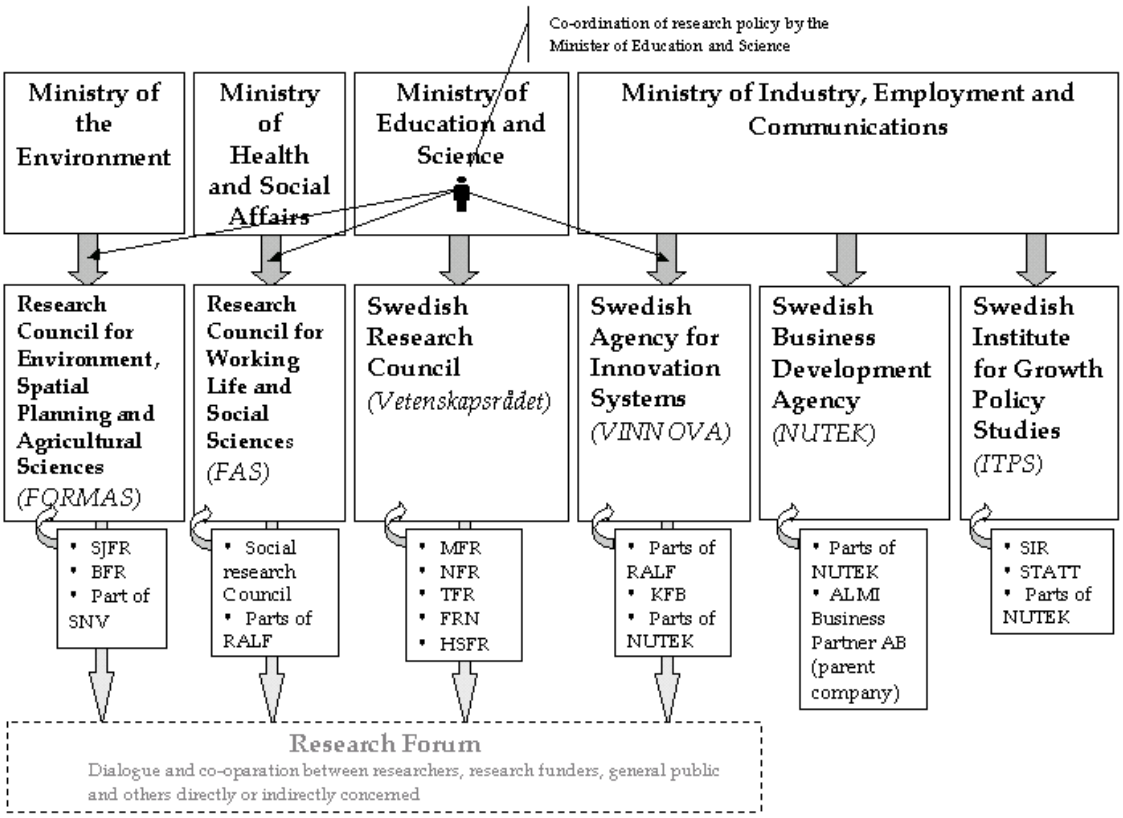
  iv. Involvement of targeted stakeholders in the design and management of the research program

The wage earner foundations represent a total capital base of about 10 billion SEK. This money is invested in the stock market and as a result of successful investment strategy many of the foundations had doubled their initial capital base by 1999. Benner (2001) provides an extensive overview of the debate surrounding the introduction of the wage earner foundations. A few issues are worth mentioning here. The first is that the original intent with forming the wage earner foundations was to provide an **additional** capital injection to Swedish research. The second is that the foundations were supposed to be independent of the government and current state research policy doctrine. Thirdly, they were supposed to work directly for promoting collaboration between universities and firms and for the commercialisation of academic research. Once the social democratic party regained control of the government, it devoted a great deal of time and effort in trying to disband the wage earner foundations and it was only in 1998 that they were officially accepted. In the meantime, the government has become more influential although indirectly in many of the foundations and through a policy of reducing public research budgets it has managed to dilute the potential effect of the wage earner foundations. A classic example of this was the severe reduction of the research budget of the Swedish Environmental Agency (Naturvårdsverket) to the point where this agency had to rely on MISTRA (the wage earner foundation for strategic environmental research) to fund projects to which the Swedish Environmental Agency had already committed.

A further change in the system for funding public research was introduced with the reorganisation of the research council system. The older system was characterised by a radical heterogeneity and a large number of actors, this system was radically restructured and in 2000 a new organisational structure was introduced.

Figure 5.1 provides an overview of the new organisational structure and shows how the older structure relates to the present day system.

Figure 5.1: Overview of the Swedish research council system



Source: This figure was kindly provided by the Innovation Systems section at VINNOVA.

Institutional Framework for Commercialisation

After the initial act of introducing the wage earner foundations, a series of policy and institutional measures were taken between 1994 and 2002 all intended to reorient the public R&D system towards more strategic goals. One of the more significant components of this policy for reorientation is the set of policy and institutional measures designed specifically for the promotion of university interaction with industry. One of the more problematic aspects of this particular area of Swedish

research policy is that it is very diffuse. While it is fairly easy to identify and describe the new policy measures and institutions, these are part of a seamless web of rules, practices, initiatives and structures many of which predate the more overt actions and initiatives to promote university-industry interaction.

One of the reasons for this is that university-industry interaction is itself only one pillar albeit a central one, in what is best described as Sweden's policy for innovation. The centrality of Sweden's universities to its innovation policy is a direct outcome of the fact that these institutions dominate the public R&D infrastructure because of the country's commitment to the Humboldtian model of keeping research and education in the same institutional context. This also implies that the focus found in Swedish innovation policy on universities may not be applicable or desirable in other countries where the public R&D structure is more heterogeneous or where the universities are not as strong in research. Briefly the policy for reforming the university sector has three pillars:

1. Promotion of the development of an entrepreneurial culture at universities and university colleges;
2. Reform of the institutional framework for competitive research funding; and
3. Expansion and upgrading of the regional university colleges while integrating them in regional strategies for economic development.

According to the Ministry for Trade and Industry, the primary framework structure for promoting the interaction between university and industry consists of five organisations: Vinnova, the National Agency for Energy, the industry research institutes, the engineering science academy and the technology bridge foundations. In table 5.2 below we provide a short summary of the main functions of these organisations. With the exception of the industry research institutes and the

engineering sciences academy, all the organisations charged with directly promoting U-I interaction do not predate the 1990s. While these organisations may be regarded as the frontline of U-I interaction, in order for them to be able to have any impact on the system as a whole a series of other interventions had to be made. These include the promotion of an entrepreneurial culture at universities and institutional support structures for supporting the emergence of this culture.

Table 5.2: List of actors directly responsible for university-industry interaction

Organisation	Description and History
Agency for Innovation systems (Verket för innovationssystem) Vinnova	Vinnova was established January 1,2001. The agency formally took over the responsibilities of three agencies that already existed. These were: the Research council for Communication kommunikationsforsknings beredningen, KFB), the part of the National Board for Industrial and Technical development (Närings- och teknik utvecklingverkets, NUTEK) that financed research and development and parts of the research council for working life research (Rådet för arbetslivsforskning; RALF).
The National agency for energy (Statens energimyndighet), STEM	The national agency for energy was formed on January 1, 1998. Its responsibilities are to coordinate and implement the main part of the actions needed to restructure the energy system. The energy agency is a central actor in research, development and demonstration of new energy technology.
Industry research institutes	The industry research institutes are financed jointly by the state, the knowledge and competence foundation (KK-stiftelsen) and the corporate sector. They conduct research within a particular industry or area and function as an important resource for the transfer of knowledge to among others the small and medium sized companies.
Technology Bridge Foundations (Teknikbrostiftelser)	The Technology Bridge Foundations are located in seven university or university college areas from Luleå in the north to Lund in the south. The

	foundations contribute to increased knowledge exchange between universities, university colleges and industry so that companies can get access to the knowledge produced in universities and university colleges.
The Royal Academy of Engineering Sciences (Ingenjörsvetenskapsakademin), IVA	The Royal Academy of Engineering Sciences promotes the engineering sciences and entrepreneurship in industry in order to achieve social development.
University Holding Companies	Eleven University Holding Companies were formed in 1994-95 for financing the commercialisation of patents. Their mission is to form project companies in order to exploit research from the universities and to develop services for such exploitation. The University Holding companies give universities and university colleges a better opportunity to improve their work with the third mission.

Factors that affect the commercialisation of academic research

The above instruments and initiatives taken by the Swedish government to promote the commercialisation of academic research are premised on the view that Sweden's investment in higher education and research is currently much higher than its output in terms of innovation measured in patents. An analysis of the thrust of the initiatives gives a good idea of the current policy perception of the main drivers of commercialisation of academic knowledge: enterprise culture; infrastructure for commercialisation of knowledge and steering mechanisms that could promote innovation policy needs in competitive research regimes.

The emphasis on enterprise culture in general and on universities in particular is a reflection of a general policy direction among EU countries and one might argue that the UK started this trend during the Thatcher administration. Locally, there is a general view that Sweden lacks an entrepreneurial culture. Some of the indicators that would lend support to this view include the R&D investment to innovation ratio, the

relatively low rate of firm formation; the large size of the public sector and the large firm bias that seems to be built into the economic structure. However, this particular description of the problem focuses mainly on discrete issues without addressing in any concrete way, the role of public intervention given these issues. Posed in this fashion, the main issue for Sweden appears to be that of how to move from an intervention model based on public procurement for infrastructural development (telecommunications, defence etc.) to a more differentiated one in which direct investment in R&D is the preferred policy tool for stimulating innovation. The benefit of posing the question in this fashion is that it both explains why Sweden seems to have taken a more holistic approach to innovation policy (i.e. the entire RTD system has been gradually subjected to reform) and raises the issue of whether a broader discussion about what kind of instruments are available and which are most appropriate should be introduced.

Remaining with the issue of entrepreneurship, it was soon realised that the higher education and research system in Sweden was one that actively promoted a set of values and behaviours that did not favour entrepreneurship. For this reason, the policy package for promoting the commercialisation of academic knowledge places unusually high emphasis on promoting the emergence and development of enterprise culture at Swedish universities and colleges. At the same time as efforts are being made to change cultural values, the infrastructure for supporting the new set of values is also being put into place often through the same mechanisms that are charged with softer value change activities such as network building, etc. Thus, a perusal of the policy initiatives described above would show that attention is given to bridging mechanisms which would act as facilitators for commercialisation either through capital infusions (technology bridge foundations), network and competence

exchanges (science parks, incubators, etc) or in terms of education programmes. The technology bridge foundations are for instance given a very broad brief to adapt their activities to suit their definition of the needs in the different regions to which they are attached. This has meant that together they cover a range of enterprise promotion activities such as venture capital provision; network building and patent and license support. Despite the level of investment in these activities and the fact that the technology bridge foundations and other such mechanisms are important additions, together they have not proved to be the stimulus for innovation expected. A recent article by Henrekson and Rosenberg (2001) suggested that one of the reasons for this is that there are not enough incentives at an individual level for academic entrepreneurship in Sweden.

The infrastructure for the commercialisation of academic knowledge is also deficient in so far as it is overly focused on patents and knowledge that can be packaged in the form of patents. While this is not a problem unique to Sweden but true of most EU countries, it still remains a significant barrier in so far as it encourages a distorted pattern of investment where disciplines that are perceived to be not 'relevant' to commodification processes may not be seen as worthy of strategic investments. Further, research from other EU countries and the US shows that despite the policy attention and investment in commodification, the largest source of external income for most universities still comes from grants for specific projects rather than profits accrued from patents or licenses.

Apart from the nurturing of enterprise culture and the development of infrastructure, the reform of the competitive research system is the third of the most significant category initiatives designed to promote the commercialisation of university research. This reform has been supported by a change in the structure of

funding university research to ensure that universities have to resort to the competitive funding market for a sizeable portion of their research funding. According to the National Agency for Higher Education, the goal is that at least 50% of research funding comes from competitive sources. For some universities in Sweden such as Chalmers, more than 60% of their research costs come from competitive sources. While this is in one sense a positive development, the increased reliance of researchers on external funds is a negative development in general for SME-university interaction. The reason for this is that these companies are usually very short on funds for commissioning R&D, for this reason it is very often so that university researchers prefer to work with larger firms. It could be argued that the policy of most of the strategic research councils of requiring researchers to collaborate with firms as one of the criteria of eligibility for funding would counteract this trend by providing an alternative source of SME entry into the system. This policy has limited impact for SMEs since as shown in the case studies, this would require that they are already part of a network which includes university researchers. There are few instances where SMEs who are outside of such networks seek out university researchers with a view to exploiting such opportunities.

In the competitive research arena, the wage earner foundations are generally seen as the most important policy innovation in terms of size of investment as well as approach. It is important to note that the entire research council system was reformed and a new structure introduced in 2001. The result of which is that the wage earner foundations although still important actors are no longer seen as special players. Together they represent less than 5% of the money invested in public research in Sweden but they are still in the frontline in terms of long term, collaborative programmes and large scale investments. In fact, one may argue that since the reform

of the other part of the competitive research system, the role of the wage earner foundations is taking on a sharper focus. This focus may be described as funding the development of a critical mass in new areas, (e.g. nano technology, certain branches of biotech, etc.) modernising aging structures (e.g. KK stiftelsen's recent investment in upgrading the industry research institutes) and the strategic foundation's investment in promoting research leaders among younger academics.

SME focused policy and initiatives

One of the most common reasons for state funded and organised support to SMEs is the general perception that SMEs are less innovative and devote fewer of their resources to research and development than their large company counterparts. With this in mind, we have reviewed existing material on the R&D activity particularly in relation to patenting and licensing activities.

R&D activity in SMEs

It is a bit difficult to measure R&D activity in SMEs since most statistics from the Central Statistics Bureau (SCB) are only for companies with more than 50 employees. It is however possible to look at the proportion of PhDs in SMEs, number of research based SMEs etc. Also, population mappings have been conducted since 1963 with 5-10 year intervals. The latest one was done in 1994 and suggested that R&D expenses in small companies is around 2-3.5 billion SEK, or about 10 % of the expenses of the companies with more than 50 employees (SOU 1999:89, p. 76), following an increasing trend since the 70s. Of these R&D expenses, service companies accounted for about 80 %. In 2000, SCB conducted a similar study based on a survey among companies with < 50 employees. It confirmed the increasing trend with total costs for R&D activities now amounting to about 7.1 billion SEK. Of these,

only 24% of R&D costs were allocated to the manufacturing sector. The main part of the R&D costs is found in computer and related activities, R&D, and other business services. R&D costs in the enterprises with fewer than 50 employees accounts for approximately 0.34 % share of GDP in 2000 while the 7 billion SEK figure is about 13 % of the costs of firms with more than 50 employees (SCBb).

The density of academics with postgraduate degrees [Phd, licentiate, MSc, 3 years of technical or natural science education (TN-academics)] is greater in the big company sector than in SMEs (SOU 1996:89, p. 64). In total there is less than one Ph.D. per 1000 employees in SMEs in the manufacturing sector (p. 65). In companies with less than 50 employees in the largest sectors, the vast majority lack TN-academics altogether, in the category 50-199 employees typically 8 out of 10 companies lack TN-academics in those sectors that dominate the SME-sector. For companies with 200-499 employees, at least 3 out of 10 companies lack TN-academics altogether (SOU 1996:89, p. 67-68). There has been an increasing share of TN-academics in the service sector and one reason for this might be that companies here have become more of development companies to larger companies (68). Looking at development intensive sectors, these had 70 % of the engineers but only 30 % of employment and it is mostly companies with at least 200 employees (70). Smaller companies outside the development intensive sectors, where many are suppliers to big companies, represent 30 % of employment but only 3 % of the engineers.

SMEs and Intellectual Property

During the 1990s, the Technology Link Foundation and the University Holding companies jointly set up Forskarpatent (Patents & Licensing Offices) at the major universities in Sweden to assist researchers in the patenting and licensing processes.

The Swedish Patent and Registration Office, PRV, grants patents and registers trademarks etc. also offer a number of commission services and training courses. Besides the authorities of PRV there are very few public schemes exclusively aimed at stimulating the use of the IPR instruments in SMEs (RRV 2002). For this reason we have used a number of cases in order to tease out SME experiences of the new interest in commercialisation of knowledge on the part of universities in general and more specifically how extant patent rights affect SMEs. These cases are presented later on in this report.

The central structure for SME support was reorganised and a new organisation focused on entrepreneurship and business development was introduced on 1 January 2001. Three new authorities were formed in order to achieve this transparency. The Swedish Business Development Agency, NUTEK, and ALMI Business Partner were merged to form a national competence centre for enterprise development and for the fostering of entrepreneurship. Vinnova, was given the mission to promote sustainable growth by financing research, technology and development (RTD) and developing effective innovation systems. Finally, the Swedish Institute for Growth Policy Studies, ITPS, was formed to improve the knowledge and basis for Swedish growth policy by undertaking analyses of changes with respect to institutional and technological requirements, systematic evaluations of policy measures and by securing good and relevant statistical data. Apart from the institutional structure, a number of specific initiatives were also launched for promoting entrepreneurship and small firm development. Below we have outlined a number of these.

Specific policy initiatives for SME support

National entrepreneurship programme

In order to improve attitudes towards entrepreneurship and to promote a more entrepreneurial society, the government decided on a national programme for entrepreneurship, due to be launched during 2002, and to be implemented over a three-year period. The programme's aim is to improve the entrepreneurial climate, stimulate positive attitudes towards entrepreneurs and to increase the numbers of start-ups. The main target group is young people. Several independent activities have already been tried within this field, but this programme will be the first strategic and coherent action for entrepreneurship in Sweden. The content of the programme and its different activities are currently being finalised. Apart from this more generalised top down initiative, entrepreneurship training has gradually been integrated into the tertiary education system through a number of local initiatives at universities. For example, in 1997 the first entrepreneurship school was started at Chalmers University of Technology and funded by NUTEK. This is a one year programme that is an option available to all Chalmers students and the focus is on teaching the skills needed to start a company (see http://www.entrepreneur.chalmers.se/ for further details). Similar programmes have been started at Uppsala, Linköping and Göteborg Universities.

Cluster programme

A national cluster programme was launched in September 2001 and will run from 2002 to 2004. The outline of the cluster programme focuses on methods and analyses in order to identify and support existing, as well as potential, national and regional clusters.

Environment-driven business development

The aim of the programme on environment-driven business development that started in 2001 is to strengthen the competitiveness of SMEs by stimulating them to develop their operations and their products from the perspective of sustainability. The projects are conducted in networks with active participation by SMEs. The programme takes into consideration that knowledge, maturity, and motives vary in the environmental work of companies. Applicants for project support can choose between two different themes:

• Environmentally sound products as a competitive device.

• Operational development focusing on continuous improvements.

CASES

Alfa Foods

Alfa Foods is active in the area of Functional Foods and was established in 1994. The firm has a staff of 13 equally distributed in R&D and production/sales. Their turnaround in 2001 was around 4 million US$. Alfa Foods develops, produces and to some extent distributes an oats-based milk beverage, for direct consumption, or as a foundation for other traditionally milk-based products such as ice cream, yogurt, or sauces. The process technology for producing this product, as well as the basic bacteria which is central to the production, has been patented, and is the platform for a range of oats-based milk products manufactured by Alfa Foods. Alfa Foods expects to grow rapidly in the next few years, partly due to growth in the Asian and European markets.

History of the company and its links

The founder of Alfa Foods has his roots as a researcher at the chemistry department at Lund Technical University, where he was working close to a professor who, in 1963, discovered the mechanism behind lactose intolerance. The professor also had an outspoken market orientation in his research, with links to a nearby multinational company that specialized in packaging. In 1990, on the basis of subsequent research into lactose intolerance, as well as a chance suggestion from an agricultural researcher, the founder decided to develop a non-dairy milk-replacement from oats. The company was born from this idea and the founding team consisted of four researchers. Once the company was established, the founder reduced his employment at the university to 20%. The founding researchers took out an early patent for the process technology, which they funded themselves, and short thereafter received additional funds from a farmers' cooperative.

At this stage the only input from the university consisted of informal staffing of the company orchestrated by the founder, as well as that of the research knowledge brought over into the patent. The founder also had some experience from previous commercialization activities, among others with starting up a medical equipment company. Alfa Foods brought their product to a limited European market between 1996 and 2000. In 2001 they received new growth capital from an international venture capital firm and a private placement from the founder's brother. Some researchers from the original team were bought out during the same period. From 2001 onwards, Alfa Foods increased its research effort into health promoting oat milk products and focused on high cholesterol, intestinal functions and lowering of the glycemic index. They have hired staff mainly from their research network, but also a

new Managing Director from the private sector, who had previously worked with the founder on a university-industry development project.

Current links with the university and other PROs

Alfa Foods has always worked closely with the nearby university, and considers the continuation of this connection to be critical to its future. The chemistry department from which the technology spun-out is still the most important research partner, but now there are also a number of smaller research groups, loosely related to this department as well as a research relation to clinical R&D at the university hospital in a nearby town. The company's preferred mechanism for linkage to the university consists of sponsoring and supervising doctoral students on research projects of relevance to Alfa Foods' product development. This way Alfa Foods can retain a strong linkage with the university, without simply 'co-opting' new staff. They also have a considerable input on project formulation and execution. The university has traditionally been seen as a place to do research, and not as central to the later stages of Alfa Foods' business cycle (product refinement, marketing and sales). With most of the research that Alfa Foods needs located at the university in these types of cooperative arrangements, this means that Alfa Foods can focus on coordination of product development and commercialization in-house, and together with other companies. Alfa Foods has not been in contact with any of the available 'bridging organizations' in the region, simply because the need has never arisen (and partly due to the fact that they had not yet been established at the time of the founding). However, they have had help from a network at the neighboring science park, which is a local 'meeting-place' for different kinds of academic and commercial interests. This site is seen mainly as a pre- or non-competitive idea network.

During the last year, Alfa Foods has been involved in an EU-project in the agro-food area, together with three other European universities and five companies. This project is considered an important stepping stone for future products, where the universities represent research, and new solutions are developed and tested cooperatively between the participating companies. Alfa Foods does not consider itself to be able to 'afford' more of a network presence in research or otherwise. Other public research institutes have a latent existence in the networks and are indirectly connected to Alfa Foods through their university contacts, but no direct linkages have been established, or are deemed necessary. The main linkage is with the founders' 'home department', where the exchange is rich, relevant and yet low in maintenance cost. The main source of staffing is from the university, and previous contacts with the company. University contacts are considered to be a strength in potential new employees. The informal contacts are the most important: "the company is built on people – not on written agreements". In the future, those networks which will be interesting are those which can enable Alfa Foods to identify new product concepts in related but more distant areas.

Beta Technologies

Beta Technologies is a research and manufacturing company that has been in existence since 1985. The company employed about 50 people before it was split into two separate companies in the spring of 2002. Their turnaround in 2001 was ca 8 million US$. Before the split, Beta Technologies was active in two areas: laser technology, where they provided whole laser systems, and fiber optics, where they provided components for high-effect lasers. Both areas are high-technology knowledge intensive, especially the area of fiber optics where their products are based

on patented knowledge. The market consists mainly of big Swedish companies for the laser systems part, and big laser systems manufacturers in Germany for the fiber optics part.

History of the company and its links

The company was spun off in the late 1970's from a government financed research project on laser workings which was located at one of Sweden's technical universities. The project involved two PhD students and a professor. Halfway through the project, the professor decided to start a company based on new ideas generated in the project and the potential yield from consulting services that these new concepts could generate. The PhD students continued part time at the university and part time at the new company. This company came to focus on laser measurement techniques and laser systems, and in 1984 the laser systems part was spun off and formed Beta Technologies together with another company from a Swedish consortium, which contributed with the funds for the establishment. At the point of establishment, the input from the university still consisted of the ideas developed in the research program which had formed the basis for the company, as well as academic contacts with former colleagues at the university. Over the years that followed, these contacts resulted in various research collaborations, and also in supervision of PhD-students. Apart from structural changes in ownership relations the company remained the same until the spring of 2002 when it was decided that the two areas of activity within Beta Technologies, laser working systems and fiber optics components, were better off as two separate businesses. The reasoning behind this decision was that since the two areas of activity are rather separate in terms of markets, chances for obtaining new

investors for a coming expansion would increase if they were separated into two businesses.

Current links with the university and other PROs

Beta Technologies, and especially the fiber optics division has always worked closely with the former colleagues at the technical university, where research into the field of their core technology has been undertaken continuously throughout the life of the company. This connection is considered to be very important for a number of reasons. One is that this is the only university in Sweden which conducts the kind of research on which Beta Technologies' business idea is based. The second is that the technology of the fibre optics field has now developed so that within a couple of years there will be new, fundamental problems concerning materials physics etc. that will need to be solved. Even with heavy investments in R&D, Beta Technologies cannot afford to generate this type of knowledge on its own. The company therefore has to rely on basic research conducted elsewhere. So far the exchange with the university has been conducted through informal seminars, research collaboration and supervision of PhD students and master theses. The university and the relevant research conducted there is accessible to employees. Beta Technologies' dependence on basic research conducted at its partner university means that it is beginning to become concerned that declining funding for the research group on which it is dependent may affect the company's future adversely. Other university links, albeit not very strong, have been forged through participation in EU-projects. Beta Technologies has participated in several such projects over the years, however, not jointly with any Swedish departments or institutes, but rather with German and French actors who contacted them and proposed collaboration. Within these projects the foreign partners deal with administrative matters. This is a requirement for Beta

Technologies, since they do not perceive themselves to have the time to engage in the cumbersome bureaucracy of the EU-projects.

Gamma Biotech

Gamma Biotech was established in 1989 and currently employs 35 persons after selling out a production unit in the summer of 2002. The turnover in 2001 was over 2 million USD. The business idea is based on biotechnology, bordering on Functional Foods. Gamma Biotech's business model is to never enter the final market themselves but rather to develop concepts, verify these, securing the manufacturing process and the possibilities to make products, and then sell this to interested companies producing for end customers. The technology is built around two basic micro organisms and the application of these to allergy and stomach-related diseases. They expect to grow rapidly in the near future.

History of the company and its links

In the mid 80's, a professor from an American university took a sabbatical in Sweden for family reasons. Once there he began working together with a professor at the agricultural university, with whom he discovered the antimicrobial properties of the reuteri-bacteria. They patented it, and set up a company called Gamma Biotech in a Research Park in North Carolina, because the financing possibilities were quite good there at the time. The founders had some difficulty raising capital for the company in the USA for a variety of reasons and began to look for alternatives and were eventually able to find new investors in Sweden. The two founders have remained on the board and act as external consultants. The company was established with little help from Swedish organizations although they had some contacts with one of the

regional organizations set up to assist universities with commercialization. The main source of support throughout the history of the company has come from a biotech Centre in North Carolina. This centre has provided useful contacts, manufacturing equipment etc. Already from start they also made extensive use of the research networks of the two founding researchers, and put great effort into making themselves well known to relevant researchers and developing relationships with them. This has been especially important for Gamma Biotech since the technology on which the business idea of the company is based was not generally accepted at the time of the founding of the company. Gamma Biotech's founders were therefore forced to build acceptance and interest by involving known scientists, who in turn could spread knowledge about the technology on a broader basis as well as make it legitimate towards consumers.

Current links with the university and other PROs

As mentioned above, Gamma Biotech had already from its inception worked closely with universities, and currently has direct contact with a vast number of researchers at different universities around Sweden. The core of Gamma's university network consists of a research, an agricultural and a technical university. The links to these universities take on various forms. Gamma staff supervise PhD students at various universities, and the company either finances the students itself or in partnership with other organisations for example the Swedish Agency for Innovation Systems (VINNOVA). The more research-oriented staff at Gamma Biotech also have their own personal networks that are used for meeting relevant researchers to discuss issues or projects. As they have gained a reputation after 10-15 years in business, researchers also contact them in order to discuss possible projects, and if mutual

interests can be found, it often results in collaboration. It has however taken a long time and a lot of hard work to be recognized and build this network. The main factors behind it is active use of informal networks and contacts, an ambition to build for long and lasting relations, and putting effort in finding mutual interests. Their links to academia are of vital interest for them for three reasons. Firstly, they build their business on the findings that come out of the various collaborations and projects. Secondly, they need to spread the word and gain further acceptance for their technology, something that was especially important at the outset of their business. As a result, Gamma demands that researchers that collaborate with the company publish their findings; otherwise they are not interested in collaboration. Thirdly, they are in no position themselves to pursue all research necessary for their business due to their limited resources being a fairly small company. There are usually no problems in the joint projects with academia as the general frameworks are explicitly set beforehand. Moreover, researchers mostly enjoy working with small companies and also have possibilities to influence the strategic orientation of the company through their findings. Other modes of interaction are conferences and seminars within academia. They almost exclusively use contacts with academia, and do not have collaborations with institutes or other organizations. Gamma's interaction with public research institutes is limited because the dependence of institutes on contract work limits their research interests. Moreover, Gamma prefers the 'free thinking' inherent in the academic model long-term relationships rather than short-term assignments.

Delta Sensors

Delta Sensors is active in the area of micro sensors. They have been in existence since 1994 and merged in 1999 with a German company. Currently they employ 23 people, 11 of whom work in Sweden, another 11 in Germany, and one person in the USA.

Most of the staff is in development and production, and half of them have a doctoral degree. Delta Sensors develops, produces, and markets chemical sensors components and sensor modules for air quality control, and their main customers are in the automotive, heat and ventilation, air condition, and environmental care industries. Delta Sensors has recently completely refocused its business and as a consequence its turnover was approx USD 279, 000 in 2001. They are however expecting to grow rapidly in their new line of business in the next few years and to break-even in 2004.

History of the company and its links

Delta Sensors has its roots in one of Sweden's new universities and research on Field Effect, started in the 70's. In 1989 they started doing research on chemical gas sensors, building on Field Effect technology, and in 1994 there was a company spun-off as an independent business man was given the opportunity to buy the patent. Together with some of the researchers in the research group, the company was founded as Micro Instruments with a focus on developing "electronic nose" instruments. At about the same time a German company, Micro Sensors, was founded as a couple of researchers left their research group. Micro Sensors also focused on "electronic nose" instruments and sensor components but based their products on other technologies; Metal Oxide Semiconductor and Quartz microbalance. In 1999 the companies decided to merge into Delta Sensors.

Before the merger, the two companies mainly had links with former colleagues at the two universities from which they had spun off, who also provided facilities and equipment. Also after the merger these contacts remained the strongest. Contacts with universities, laboratories, and research institutes other than the two originating universities are restricted in so far as these research organisations are

regarded as customers or potential customers for their products and thus important for the sake of feedback. In 2000, Delta Sensors realized that it had to change focus and try to reach mass markets in order to make a profit and grow. This led to the company abandoning the 'electronic nose' and turning to sensor components and sensor modules. In doing so they have not maintained contacts with their research partners more than to the extent that they still provide help or test equipment when asked for it.

Current links with the university and other PROs

They still maintain close contact with the two universities that the current company has spun off from, both informally in terms of personnel keeping contact with former colleagues, as well as formally in terms of research collaboration programs. In Sweden, Delta Sensors participates in a formal research collaboration that is a direct cooperation between the university it spun off from and about 10 industrial firms where they jointly decide upon, finance and pursue different research projects. The companies in the collaboration are of various sizes, and are involved in various areas of specialization where Delta Sensors is the only firm specialized in gas sensors. The German part of Delta Sensors has a similar arrangement with the university from which it spun off. Another important link to the university is through the financing and supervision of doctoral students. Moreover, Delta Sensors personnel attend different conferences in their area of interest as well as participating in different EU-projects that involve many different industries and universities throughout Europe. The main benefits altogether of these contacts with the universities are stated to be threefold; they acquire research results that they can develop into products, the universities are good bases for recruitment, and it is also stimulating for the

researchers working at Delta Sensors to maintain their contacts. Especially acquiring research results is important because being a small company, they cannot afford doing both research and development. They are thus using the university for the research part and are doing the development themselves, which leaves them with a fairly high dependence on the universities. This is sometimes a bit awkward since they can ask for research to be conducted in some areas, but have to rely on that the university perceives it as challenging and worthwhile to pursue in order to get it done.

Policy Conclusions

In summary we provide a number of policy conclusions. These findings are organised under three headings: universities, government and finally the SME sector itself depending on which actor should take the lead in integrating the insight in action. A further attempt is made to select from each of these findings one critical action point for each actor. This action point is differentiated from the others by using shaded text.

SME lobby organisations

Policies for improving knowledge access to SMEs are still trapped in the logic of the linear model

Despite the prevalence of innovation systems rhetoric in the policy literature on Swedish innovation policy, the actual policy mechanisms are still rooted in the linear model. The emphasis on universities blinds policymakers to the fact that they are not even the main knowledge providers to the vast majority of SMEs. This is in part a result of the dominance of universities in the Swedish public R&D system and the explicit policy emphasis on promoting high tech SMEs. More importantly, however it is an outcome of the general ignorance of the knowledge seeking behaviour patterns

of SMEs. There is a need to explore mechanisms for supporting the formation of firm-firm networks; trade fairs and transfer of personnel. SME lobby organisations are better placed to promote initiatives of this type since they are in a better position to know member needs, etc. More interaction between policymakers and SME lobby organisations, industrial representatives is needed if future policies are to improve.

Government agencies

Need for improvements in policy design

After more than a decade of reform and new initiatives the public R&D system in Sweden is best described as complex and no complete overview exists. An examination from the point of view of the needs of SMEs shows however that a number of coordinative mechanisms need to put in place. Among these, two issues stand out as requiring attention. One is the need to draw on the wealth of existing research which shows that social proximity is a significant predictive factor in determining the knowledge seeking behaviour of SMEs.

One way to integrate this in policy design is for example to assist universities to develop differentiated structures for university-firm interaction. The present technology transfer office approach may be functional for larger companies or even those with a history of university networks but it may be worthwhile to apply an approach based on the agricultural extension services model for SMEs in the traditional sector.

The strong regional dependence of SMEs could also be more directly reflected in funding policy. The KK stiftelsen's programme of giving priority to funding research at university colleges may for instance be more explicitly integrated into a system for funding collaborative research between SMEs and university colleges.

This programme could also be broadened to allow the older universities access to this funding for their collaborative research projects with SMEs.

Vinnova's recently introduced VINNVÄXT programme which targets winning regions and provides support is a promising development in terms of policy design and initiative. The programme is an encouraging deviation from the principle of equal distribution that has characterised regional development. More importantly however the fact that SMEs are for the most part more dependent on their regional context implies that should VINNVÄXT prove to be a success, one can expect that the SMEs in those regions to derive positive externalities.

Entrepreneurship education a positive contribution to promoting enterprise culture in the long and short term

Current efforts to promote enterprise culture are quite wide ranging in Sweden and one of the best practice cases is undoubtedly the entrepreneurship school at Chalmers which was started with a NUTEK grant. This model has been replicated at a number of universities. Effort should be made to promote enterprise culture in other ways throughout the society. Two key issues need to be considered in this context, Swedish programmes for support are still overly focused on technology based companies. The service and other sectors are equally capable of producing high growth, successful companies. Given the changing demographics of the country, this source of economic restructuring may be not only necessary but imperative if Sweden is not to lose this potential income to other countries. A second factor is that the promotion of enterprise culture outside of the PRO sector needs an image change since previous policies have created an association between entrepreneurship and unemployment

relief programmes. An initial point of departure would be a nation wide public education programme media and other forms of outreach. Such a programme would be both informational and normative. Informational in that it would provide information on where to turn if one wants to create a company. A normative aspect would also have to be included. Creating one's own company should be portrayed as a positive and creative step.

Strongest predictor of SME- University interaction is level of education of staff of SME

Social proximity appears to the strongest predictor of whether SMEs will have ties to PROs. Social proximity is determined by the level of education of the employees in the SME and origin (university spin-offs continue to network with their source university and department). This implies that more indirect policy measures such as improving the level of education of the population as a whole are still important for improving the level of collaboration between SMEs and PROs

Shift in focus from SME support to Entrepreneurship

In general, it may be argued that in the last decade Sweden has developed an impressive range of mechanisms for promoting commercialisation of academic knowledge. The majority of these mechanisms are not directed specifically at SMEs but do not exclude them either. The shift to entrepreneurship as opposed to SME assistance has both positive and negative implications. On the positive side, the emphasis on firm formation and young, small firms will benefit SMEs in general. This has led to among other things new initiatives to upgrade SME competence profiles through programmes such as VINNOVA's SEK 12 million programme

focused on upgrading SME competence. On the negative side, there is an explicit bias in current policy towards high and new technology based firms particularly those linked to universities. This implies that SMEs in the more traditional parts of the economy will have trouble accessing some of the newer support programmes.

Universities and PROs still require a great deal of support and resources for organisational development

Universities and PROs but particularly universities in Sweden lack the managerial and administrative competence to deal with the commercialisation of knowledge. Inputs from institutions such as the Technology bridge foundations have been vital sources of competence and capital. These resources are not only short term (the Technology Bridge foundations are scheduled to be phased out by 2007) but limited and cannot help with upgrading and cultural shift needed in the administrative cadre of Swedish universities. University holding companies are notoriously underfinanced and dependent on the Technology Bridge Foundations. It is still a grey area whether this solution is workable for all universities or whether more effort should be put into diversifying ownership and missions of universities.

Universities

Universities will need to devote more attention to governance mechanisms for competitive and collaborative research as well as commercialisation activities. Support mechanisms for project management, contract diversification, leadership development at the institutional level, etc. will have to be created. At present there is a fundamental dichotomy between the requirement that universities become entrepreneurial and the fact that Swedish universities are not homogeneous but

coordinating organisations. This means that a great deal of initiative and impetus for action lies with the individual researcher rather than with the department, faculty or university. If universities are to meet the new demands, effort will have to be made to encourage the development of units that take responsibility for the performance of the collective.

References

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Bonaduce, A., Fariselli, C., Rau, C., Praneuf, I., and Bellotti, C. 1997. About Technology Transfer. Third Review Meeting – Bologna, 25-26 Sept 1997, COMPETE 21865.

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OECD (2002) Small and Medium Enterprise Outlook, Paris: OECD

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Riksrevisionsverket. 2001. Från forskning till tillväxt – statligt stöd till samverkan mellan högskola och näringsliv. Effektivitetsrevisionen 2001:11

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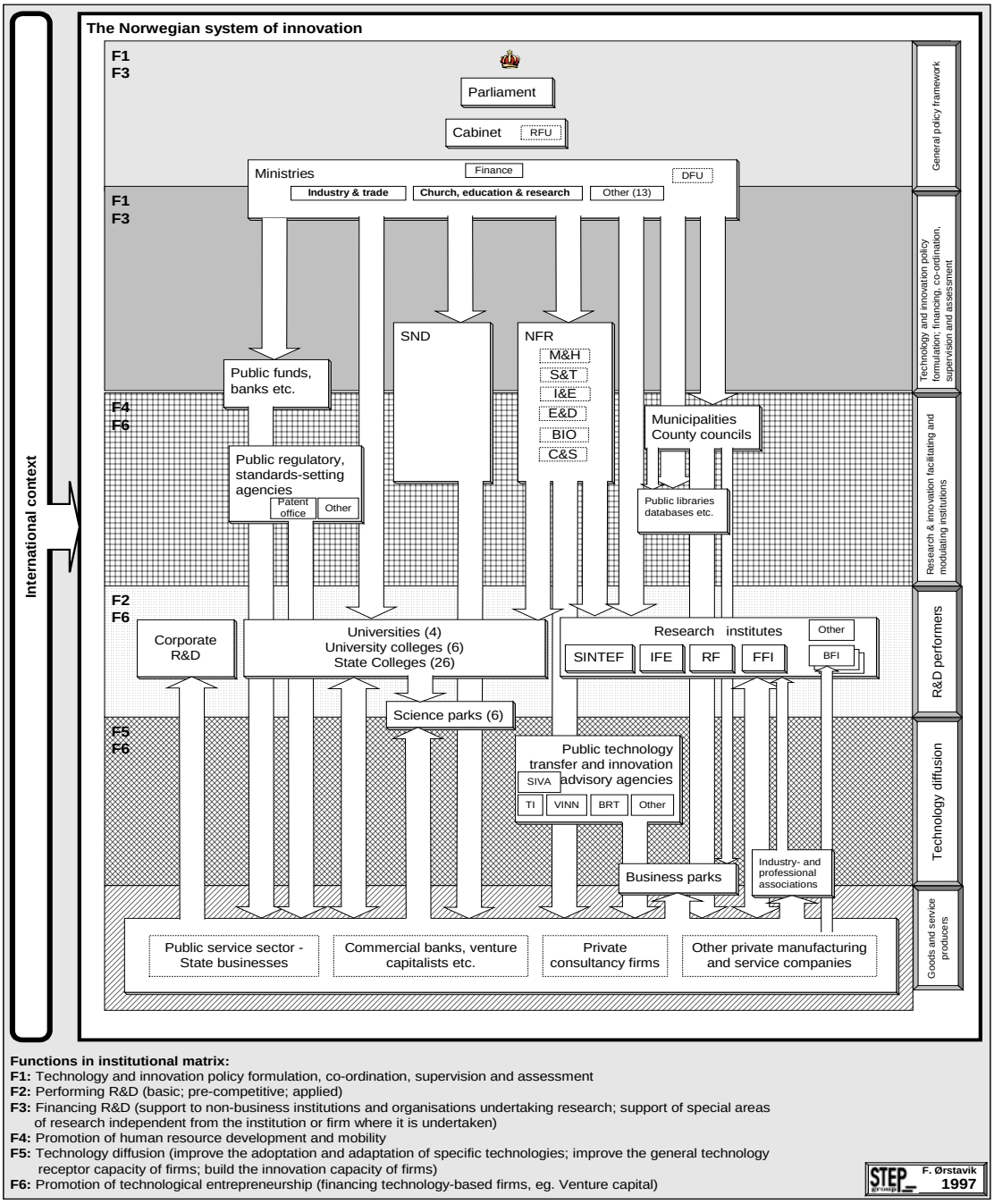
Appendix 1: A policy-centered organisational map of the Norwegian system of innovation



Source: Ørstavik. Step-Working Paper 1/98.

Appendix 2: Outline of organizations in the Danish research system

Universities:

Aalborg University
http://www.auc.dk
Aarhus School of Business
http://www.hha.dk
Copenhagen Business School
http://www.cbs.dk
Roskilde University
http://www.ruc.dk
Royal Danish School of Pharmacy
http://www.dfh.dk
Technical University of Denmark
http://www.dtu.dk
The Royal Veterinary and Agricultural University
http://www.kvl.dk
University of Aarhus
http://www.au.dk
University of Copenhagen
http://www.ku.dk
University of Southern Denmark
http://www.sdu.dk
The IT University in Copenhagen
http://www.it-c.dk
Danish University of Education
http://www.dpu.dk

Sectoral research institutions

Amternes og Kommunernes Forskningsinstitut
http://www.akf.dk
Analyseinstitut for Forskning
http://www.afsk.au.dk/
Arbejdsmiljøinstituttet
http://www.ami.dk/
Center for Regional- og Turismeforskning, Bornholm
http://rcb.dk/
Center for Freds- & Konfliktforskning
http://www.copri.dk/
Center for Sprogteknologi
http://www.cst.ku.dk/
Dansk Bilharziose Laboratorium
http://www.bilharziasis.dk/
Institut for Grænseregionsforskning
http://www.ifg.dk/

Danmarks Fiskeriundersøgelser
http://www.dfu.min.dk/
Danmarks JordbrugsForskning
http://www.agrsci.dk/
Danmarks Miljøundersøgelser
http://www.dmu.dk/forside.asp
Dansk Rumforskningsinstitut
http://www.dsri.dk/
Danmarks Transportforskning
http://www.rft.dk/under1/dtf.htm
Dansk Udenrigspolitisk Institut
http://www.dupi.dk/
Forsvarets Forskningstjeneste
http://www.ddre.dk/
Forskningscentret for Skov & Landskab
http://www.fsl.dk/
Fødevaredirektoratet
http://www.fdir.dk/
GEUS Danmarks og Grønlands Geologiske Undersøgelser
http://www.geus.dk/
John F. Kennedy Instituttet
http://www.kennedy.dk/
Forskningscenter RISØ
http://www.risoe.dk/
Statens Byggeforskningsinstitut (By og Byg)
http://www.sbi.dk/
Socialforskningsinstituttet
http://www.sfi.dk/
Statens Institut for Folkesundhed
http://www.dike.dk/
Statens Jordbrugs- og Fiskeriøkonomiske Institut
http://www.sjfi.dk/
Statens Serum Institut
http://www.ssi.dk/dk/
Statens Skadedyrlaboratorium
http://www.dpil.dk/
Statens Veterinære Institut for Virusforskning
http://www.vetvirus.dk/
Statens Veterinære Serumlaboratorium
http://www.svs.dk

Research councils

Statens Humanistiske Forskningsråd
Statens Jordbrugs- og Veterinærvidenskabelige Forskningsråd
Statens Naturvidenskabelige Forskningsråd
Statens Samfundsvidenskabelige Forskningsråd
Statens Sundhedsvidenskabelige Forskningsråd
Statens Teknisk-Videnskabelige Forskningsråd

Forskningsstyrelsen
Danmarks Forskningsråd
Forskeruddannelsessrådet

Other research funded agencies

Danmarks Grundforskningsfond
Vækstfonden
Erhvervsfremme Styrelsen
Akademiet for de Tekniske Videnskaber
Carlsbergfondet
Kræftens Bekæmpelse

Technological service institutions

Institutrådet
Bioteknologisk Institut
Dansk Brandteknisk Institut
Dansk Hydraulisk Institut - Institut for Vand og Miljø
Dansk Institut for Fundamental Metrologi
Dansk Maritimt Institut
Dansk Standard
Teknologisk Institut
Dansk Toksikologi Center
Delta - Dansk Elektronik, Lys & Akustik
dk-TEKNIK
FORCE Instituttet
Institut for Designrådgivning
Danmarks Meteorologiske Institut
Dansk Center for Migration og Etniske Studier
Dansk Polarcenter
Det Danske Center for Menneskerettigheder
Institut for Sundhedsvæsen

Science parks

Agro Business Park Denmark - Forskerpark Foulum
Forskerparken i Aarhus
Forskerparken CAT
Forskerparken Fyn
Forskerpark NOVI
Københavns Forskerpark Symbion
http://www.innovation.dk/indexin.html
http://www.dtu-innovation.dk/
http://www.hih-development.dk/
http://www.tekinno.dk/
http://www.innovation.sp-aarhus.dk

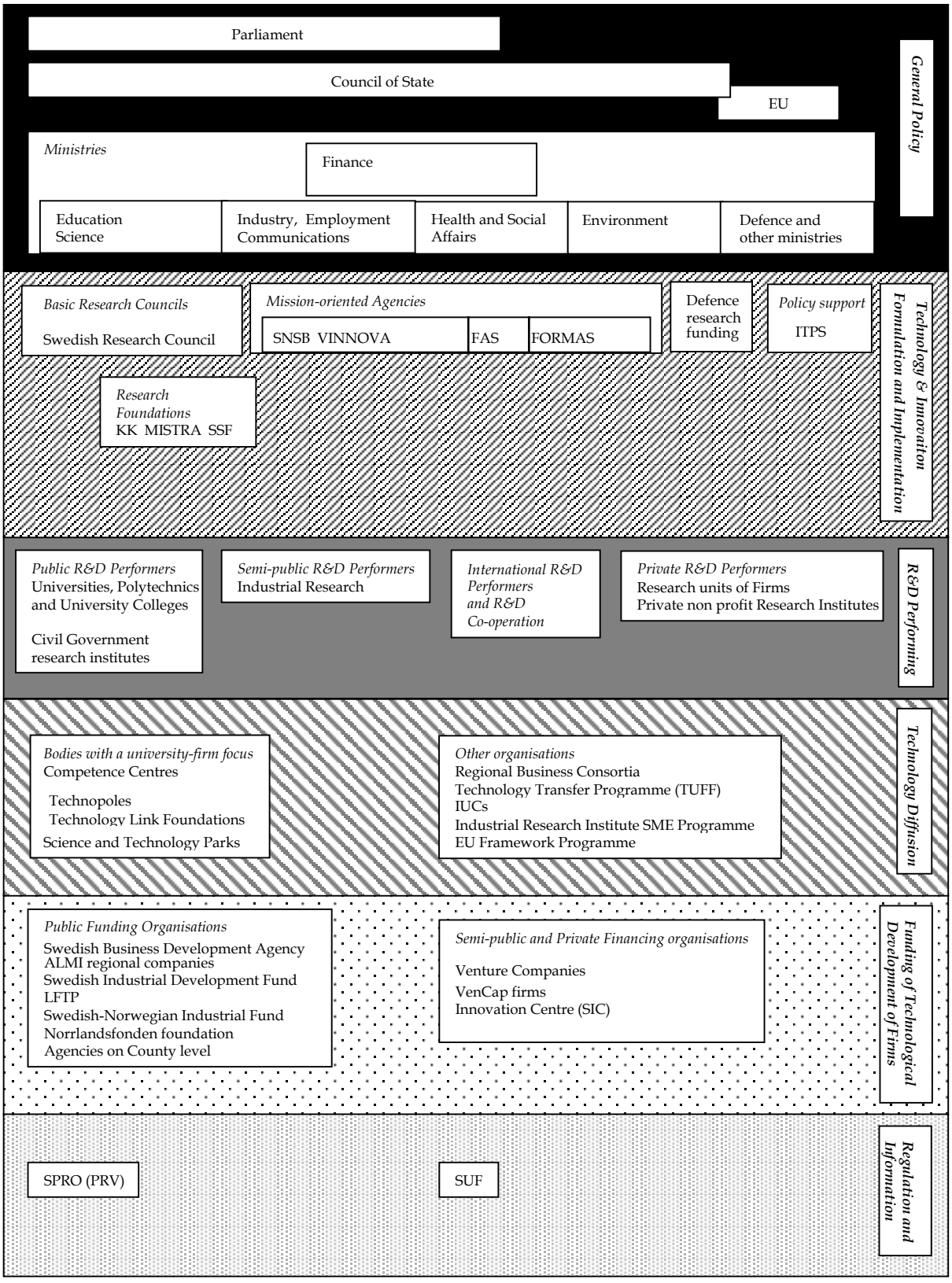
Appendix 3: General data on Danish universities

	Result, 1000 DKK	STÅ**/Intake	Personel VIP	Personel TAP	Ph.D.	Publications	Patents
KU	5.300	16371/4802	2491	2270	1211	4717	n.a
KVL	-13.7	1873/412	676	800,2	450	862	1
DTU	14	3853/1359	1263	n.a	680	894	16 (39)
CBS	11.645	6217/5714	585	440	199	1116	0(2)
DFU	5.574	827/	207	151,6	140	n.a	n.a
RUC	2.800		463	89,6	245	1274	n.a
SDU	-42.001	6176/2089	965	n.a	457	n.a	n.a
HHÅ	6.551	n.a	261	202	n.a	n.a	n.a
AU	0.72	11356/	1546	n.a	709	3756	0(11)
AUC	10.945	6895/2531	1022	705	440	n.a	19 (22)
IT-C	1.938	436	48	n.a	27	68	n.a
DPU	n.a	n.a	n.a	n.a	147	n.a	n.a

*n.a: not available

** Studenterårsværk, equals 60 ECTS

Appendix 4: Organisations in the Swedish Innovation System



Source: Vinnova, Systems of Innovation section

Appendix 5

Recent Studies on SME cooperation with PROs or universities (Sweden)

Norgren, Lennart & Lars Olsson (2002) Stimulating International Technological Collaboration in Small and Medium-Sized Enterprises. A Study of VINNOVA's SMINT Programme. VF 2002:2 (Can also be downloaded from www.vinnova.se), Stockholm, Sweden, National Agency for Innovation Systems

Ullström, Jonny, (2002) Det Svenska Nyföretagandet 1986-1997 - förändringar i företagsstrukturer och sysselsättningseffekter, VINNOVA, Report number VA 2002:2, (Can also be downloaded from www.vinnova.se), Stockholm, Sweden, National Agency for Innovation Systems

Royal Academy of Engineers (2002) Utveckling av tillväxtföretag i Norden, Rapport från ett nordisk samarbetsprojekt mellan Akademiet for de Tekniske Videnskaber (ATV), Norges Tekniske Vitenskapsakademi 8NTVA), Stiftelsen for industriell og teknisk forskning ved NTH (SINTEF) och Kungliga Ingenjörsvetenskapsakademien (KVA), Stockholm

Andersson, et al. (2002) En liten bok om tillväxt, ITPS, NUTEK, VINNOVA

Henreksson, M. (2001) Akademiskt Entreprenörskap, Stockholm, Studieforbundet Näringsliv och Samhälle (SNS)

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