Collaboration between manufacturing firms and knowledge institutions on product development

- evidence from harmonised surveys in Australia, Denmark, Austria, Norway and Spain.

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OECD National Innovation System. FG on ccn, module 1.

1. Introduction

Suggested main-author: JLC

The present paper focus upon a key feature of innovation systems, the collaboration between firms in industry and what is here broadly termed knowledge institutions. It is researched what types of firms have this collaboration, are there any country differences in this respect, and what are possible motivations for entering such collaboration.

In the past 10-15 years there has been considerable developments in the perception of innovation processes. Today, there seems to be little disagreement with the fact that technological innovation proceeds as a complex interaction between research, design, production and marketing and takes place in a seamless web of interactive learning between a variety of actors at all levels in the economy (Lundvall, 1992); multiple sources of information and pluralistic patterns of collaboration seem to be the rule rather than the exception.

If innovation was pursued by atomistic agents acting in isolation there would be little reason to look for 'systems' of innovation. The concept of a 'system of innovation', which have been widely used in the literature on innovation in the past decade, is therefore deeply rooted in the belief that innovation is an interactive process where agents and organisations communicate, co-operate and establish long term relationships. The innovation system concept have been used both in a broad sense and a narrow sense, the latter mainly denoting the knowledge infrastructure and institutions directly relevant for innovations, and the former also encompassing the functioning of a wider set of institutions in the economy as well as informal institutions. Although the present paper focus upon knowledge institutions, then innovation systems will be discussed also according to a broader definition.

One of the findings from recent research on innovation systems is that there is a considerable variation between national innovation systems in terms of the extent to which firms interact with different collaboration partners and in terms of whether collaboration is pursued with domestic or international partners. Investigating patterns of inter-firm collaboration, is useful in order to highlight these differences between national innovation systems. The issue is relevant not only because of the pertinent role of inter-firm collaboration in innovation systems. There are trends in the economy related to internationalisation, new technology and new modes of knowledge production which make such a study more important than ever.

Despite an increasing awareness of (and agreement upon) the importance of inter-firm linkages and linkages between firms and knowledge institutions in connection with product innovation, few attempts have been made to systematically collect empirical data mapping such relationships enabling cross-country comparisons. In spite of obvious inherent potentials in applying such a perspective, the analysis of innovation systems has only to a limited extent and with a narrow focus pursued systematic international comparisons in these respects. So far, comparative data have been mainly case study based.

Moreover, the present study focus upon collaboration (including informal collaboration) on product innovation, whereas previous studies mainly deal with formal agreements on R&D. This is an important difference and has a bearing on our focus. As we know from innovation research that product innovation is something broader than R&D we would also expect collaboration to be much broader than what has been shown in relation to R&D-collaboration.

Therefore, rather than just focusing upon R&D-institutions like universities, we take a broader approach and define not only universities and other research institutions, but also technical institutions, consultants relevant for product innovation, suppliers of technical services, institutions for certification, test, control, as knowledge institutions.

The lack of studies with this focus and the lack of data on this has been a main impetus for the initiative of a data gathering, which has been harmonised between a number of countries in order to allow international comparisons. This work has been pursued in connection with the OECD-project on national innovation systems, the sub-theme on inter-firm collaboration[1]. The countries participating in this exercise are Austria, Denmark, Spain, Norway and Australia.[2]

The paper proceeds as follows. Section 2 provide a survey of literature on inter-firm collaboration. The concluding argument in this section is that the literature has focused upon studies of formal co-operation/joint ventures as opposed to a broader perception of collaboration including informal collaboration. Previous studies have also focused upon the role of universities as opposed to the broader set of knowledge generating institutions. Related to this the major part of studies have been American, as universities play a relatively more important role than in Europe. Finally it is argued that previous studies are on R&D collaboration rather than innovation and that international comparative data on this is lacking. The ambition in present paper is to focus investigations upon these deficiencies. In section 3 are details with respect to the data explained further. We then proceeds in section 4 to present descriptive statistics on the surveys. It is concluded that these statistics alone provide useful insights but in order to investigate further a multiple of driving forces behind collaboration between manufacturing firms and knowledge institutions we need to use multi-variat analyses. A model to be estimated is therefore developed in section 5 and results from these analyses are discussed in section 6. Finally, in section 7, we point to implications of our findings for our understanding of the issue, and we point to a few general policy relevant considerations.

2. Survey of literature

Suggested main-author: JLC, Andreas, ALV

Contents:
Argument guiding the survey: Hitherto narrow focus in the literature:

- formal cooperation/Joint venture, (MERIT/CATI-data) vs also informal ccn in this paper
- Universities vs. knowledge inst. in this paper

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[1] More recent comprehensive approaches to survey the collaboration of innovative firms include the CIS- (Community Innovation Survey I and II) and the PACE-survey (Policies, Appropriability and Competitiveness for European Enterprises).

[2] Also Sweden undertook a survey similar to that of the other countries. However, it was carried out only in a region of Sweden and the data are only included in this paper as ad-hoc references.

- U.S. vs. european + Australia in this paper
- R&D vs. innovation in this paper

The point is to show the large number of articles focusing on the former point of those above, whereas the latter is much underemphasised.

Below is a first, rather general, part of a survey. It needs much more work and needs to be organised according to the idea above .

One of the most important results from recent innovation research is that innovation is an interactive process. This general characterisation of the innovation process has been 'in the air' for quite some time. The Sappho-project demonstrated the importance of interaction between departments and with customers for innovation success (Freeman 1982). Historical studies by Rosenberg (1972) emphasised the importance of interaction between users and producers of machinery for the development of the textile industry in the US. In the beginning of the eighties the Uppsala School, taking their starting point in the economics of industrial marketing, developed a series of empirical studies of industrial networks that were increasingly focused on innovation processes involving informal co-operation between firms (Håkansson 1987, Håkanson 1989 and Freeman 1991).

A major progress was the formulation of the so-called chain-linked model which explicitly was presented as a substitute for the predominating linear model of understanding innovation (Kline & Rosenberg 1986). The empirical analyses of inter-organisational collaboration in high-technology areas pursued at MERIT also pointed to the growing importance of interaction in innovation (Hagedoorn & Schakenraad 1992). In a sense, it was the report from OECDs Technology and Economic Program (TEP), that marked the official recognition in the public policy realm of the understanding of innovation as an interactive learning process (OECD 1992). Recently the Community Innovation Survey data (CIS) have been used to demonstrate that firms normally innovate in interaction with other organisations and that they interact with a multitude rather than with a single external partner (DeBresson *et al.* 1997).

Mainstream economic theory favours an interpretation where the normal and ideal state of the economy is one where agents are atomistic and individually pursue their goals. In applied economics there might be room for strategic alliances aiming at exploiting consumers but even here the main emphasis is on appropriating profits from resources already in place rather than on creating new knowledge in a co-operation involving formally independent organisations. Only recently has there been a reassessment of competition policy taking inter-firm technology co-operation into account (Jaquemin 1988, Geroski 1993, Jacquemin & Soete 1994).

There is now a large body of research focusing on the way the increasing 'globalisation' of economic activity is impacting on the advanced industrial economies. Globalisation is reflected in increased trade flows, higher rate of foreign direct investment, global sourcing and an increased incidence of inter-firm co-operation crossing national boundaries. Such tendencies can be linked to the growing importance of knowledge-based competition and are arguably both promoting and being facilitated by significant changes in the technology of information transfer and exchange.

Despite the importance of these trends towards greater economic integration, there is little evidence to suggest that globalisation is eliminating deep-seated differences among the advanced industrial economies. Significant differences can be observed not only in terms of

areas of technological and industrial specialisation, rates of productivity growth and trade performance, but also with respect to inter-firm ccn.

The increasing importance of knowledge-based competition means that companies are placing a new premium on establishing co-operative relations with firms and institutions with complimentary competencies. In this manner they seek to stay abreast of an increasingly rapid pace of innovation involving the development of new products integrating diverse technologies. There are useful case study evidence showing that differences in such national institutions as the professional training system (Lam 1998), the system of contract law (Arrighetti, Bachmann and Deakin 1997; Burchell and Wilkinson 1997) and business and trade associations (Lane 1997; Mason and Wagner 1997) impact on the form and effectiveness of these new forms inter-organisational co-operation and networking. However, our knowledge of the links between knowledge institutions and inter-organisational ccn remains quite limited. As of now, there are no studies providing evidence across a large number of European nations based on the use of a common methodology.

3. Data

In all international comparisons an important precondition is a rather strict definition of the concepts used in data collection, agreement on sampling methods, the exact formulation of questions etc. The experience from previous surveys such as the CIS is that it has proven a very difficult task to ensure comparability across the participating countries by agreeing upon a common approach and a set of guidelines for empirical work. As one element in harmonising the method for collecting empirical data on patterns of inter-firm collaboration in product innovation, the participating countries have agreed upon using CATI (Computer Aided Telephone Interviewing).

Besides the agreement upon using CATI, a set of common questions to be used as a reference point for the participating countries has been formulated. Main categories of questions refer to:

* type of partner
* reason for and importance of collaboration with the specific type of partner
* duration and intensity of collaboration
* mobility of labour during collaboration
* services related to product development

There are at least three major differences with regard to the data generated within this project and the data obtained from most other surveys. *First*, the focal point with regard to collabo-

ration in the present survey is on innovation and not on R&D as in the first round of CIS[3]. Second, in CIS the focus on the use of external information sources primarily concerns the spark to the innovation process, whereas the present survey opens up the possibility for revealing with whom firms collaborate in carrying through the innovation process. Third, the focus on product innovation only and the use of telephone interview instead of postal survey makes these survey more specific.

Table 1 shows the sample distribution and the response rate of the participating countries. All samples were selected randomly among the manufacturing industry with firms with 10 employees or more.[4] The participating firms in the countries represent in a broad sense the population of the firms concerning industry and size. Except from Austria who has a response rate of 92%??? the response rates of the rest of the countries are between 62% and 74% which is satisfactory. The overall rate is 72%.

Table 1: Sample distribution and response rate

Country	Contacted firms	Participated successfully	Response rate
Australia	1003	622	62%
Austria	1006	927	92%??
Denmark	1500	1022	68%
Norway	1081	797	74%
Spain	594	400	67%
Sweden (western region)	954	669	70%
All countries	6138	4437	72%

(to end this section: a bit on pros and cons of the data)

4. Descriptive statistics on the results from surveys

Suggested main-author: Andreas, ALV

Contents:

- propensity to collaborate by country, size, industry
- details on Universities and other knowledge inst. treated in this paper
- in notes include some of the key results from the Swedish survey

the summary report entails the text below (adjust + more, include tables + figures.) Concluding section=what should be further analysed.

[3] A second CIS survey, building on the methodological and analytical lessons learned in the first phase (1991-1993) was launched in 1997. Here, the question on R&D collaboration has been replaced with a question on innovation and collaboration.

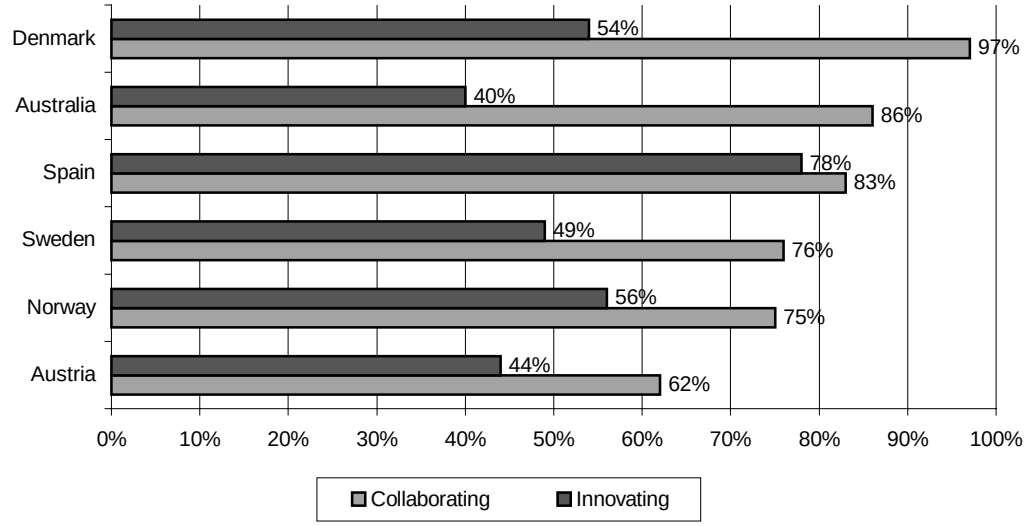
[4] In the Australian survey firms with less than 10 employees were included as well.

The CIS-surveys as well as the EuroDISKO-surveys carried out in Australia, Austria, Denmark, Norway, Spain and Sweden bear evidence to the fact that firms frequently collaborate on product innovation. It should be stressed that the data show the share of firms who within a two-year period have tried at least once to collaborate on product innovation. This does not mean that all firms collaborate every time they develop new products[5].

As depicted in figure 4.1, in Austria 44% of the firms in the sample had developed one or more new products within the last two years of which 62% of firm claim to have collaboration with one or more partners on at least one of their product innovations. In Norway 56% of the firms indicated having developed one or more new products of which 75% indicated collaboration. In Sweden the percentages are 49% and 76% receptively. In Spain 78% of the firms had developed one or more new products within the past three years of which 83% collaborated with one or more partners while in Australia 40% had developed new products and 86% in collaboration. In Denmark, of the 54% that indicated having developed one or more new products within the last two years the proportion indicating collaboration was as high as 97%.

[5] The results in the Danish DISKO survey showed that 59% of the firms in more than half of the cases collaborates with external partners in the process of product developement.

Figure 4.1: Percentage of firms innovating and collaborating in participating countries (unweighted)



Source: Australian DISKO survey (1999); Christensen *et al* (1999); Edquist *et al.* (2000); Ørstavik and Nås (1998); Sanz-Menéndez *et al*. (1998), Schibany (1998).

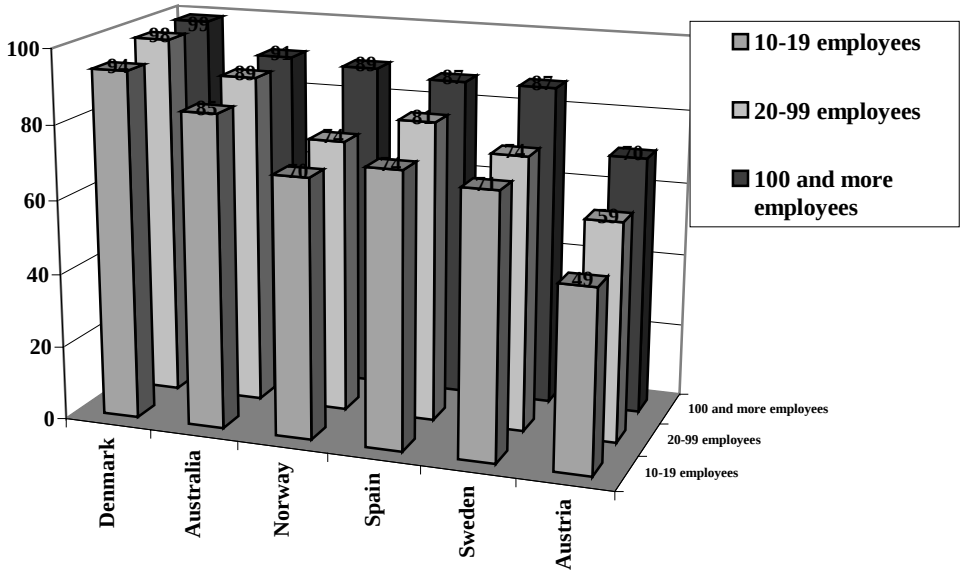
The surveys enable us to compare the six countries in terms of whether product innovation is positively correlated with firm size. In all countries the data bear evidence to the fact that *there seems to be a positive correlation between firm size and product innovation.*

As shown in figure 4.2 at a general level the propensity to collaborate rises with firm size. In Austria the tendency is most clear: Whereas 49% of small product innovating firms (10-19 employees) have collaborative arrangements the percentage increases to 70% for large product innovating firms. In Denmark a surprisingly high percentage of small firms (94%) indicate collaboration and close to all large product innovating firms in the sample (99 %) have collaborated. In Norway 70%, Sweden 71%, Spain 74% and Australia 85% of small firms indicate collaboration increasing to 89% for Norway, 91% for Sweden, 87% for Spain and Australia for firms with 100 employees and more.

The results are quite as expected. In general large firms are more often engaged in product innovation.[6] Hence, it can be expected that they are more likely to collaborate with one or more external partners. Also, external relations are often interpersonal. Having more employees, the likelihood that a large firm has at least one collaborating partner increases (the survey includes formal as well as informal collaborative arrangements).

[6] But the number of product development per employees is not higher than for small firms. In the Danish DISKO survey the number of product development per employee was 0,3 for firms with 10-19 employees while it was 0,1 for firms with more than 50 employees.

Figure 4.2: Percentage of firms collaborating in the development of new products by firm size in participating countries (unweighted).



Source: Australian DISKO survey (1999); Christensen *et al* (1999); Edquist *et al.* (2000); Ørstavik and Nås (1998); Sanz-Menéndez *et al*. (1998), Schibany (1998).

There is considerable variation across countries with regard to the frequency of collaboration with different types of collaboration partners.

Table 4. Error! Unknown switch argument.**: Distribution of collaboration partner(s) in participating countries, percentage (unweighted)**

	Austria	*Denmark*	*Norway*	*Australia*	*Spain*	*Sweden*
Customers private	56	71	59	64	53	61
Customers govt	33	21	20	15	-	30
Suppliers of materials and components	62	74	57	52	58	83
Suppliers of machinery and production equipment	20	44	35	26	49	55
Suppliers of technical services, testing and control	42	43	45	-	-	42
Marketing, management consultants	18	32	18	28	33	-
Competitors	20	3	28	7	15	35
University and research centres	33	17	23	17	60	36
Parent/subsidiary	39	33	-	30	37	-

Source: Source: Australian DISKO survey (1999); Christensen *et al* (1999); Edquist *et al.* (2000); Ørstavik and Nås (1998); Sanz-Menéndez *et al*. (1998), Schibany (1998).
Note: Firms can have more than one collaboration partner.

The striking feature of these results is the importance on the one hand of customers (both private and government), and on the other hand of suppliers of materials and components. Once again, the results here seem to be rather robust across countries. These results confirm one of the core hypotheses of the national innovation systems literature, namely that user-producer interaction is at the core of interactive learning in the innovation process. Neither customers nor input suppliers should be seen as conventional market traders, simply buying a well-defined product on the basis of price or quality, but rather as technological collaborators, helping to define product characteristics and attributes, and helping thereby to shape new product innovation.

(THE FOLLOWING SHOULD BE ADJUSTED ACCORDING TO THE FOCUS ON KNOWLEDGEINST. RATHER THAN UNIV.)

The pervasiveness of user-producer interaction, however, should not blind us to other collaboration partners. One of the most striking differences is with respect to universities and research centres which are very frequent collaboration partners for Spanish firms (60%), rather frequent collaboration partners for Swedish (36%) and Austrian firms (33%) but not very frequent as collaborating partners for Danish and Australian firms (17%). In the case of Norway, the 23% only refers to the use of universities as collaboration partners. 41% of the Norwegian firms have indicated co-operation with research institutes.

A possible explanation for this feature might be found in differences in institutional set-ups. One of the reasons why firms in Denmark might not use universities and public research institutions as frequently as collaborating partners compared to product innovating companies in other countries could be the broad range of technological services offered by intermediate technological service organisations which are part of the Danish GTS-system (Approved Technological Service System). Also, as pointed out by Sanz-Menéndez et al. (1998) the relevance of universities and public research centres as central actors within innovative networks is also controlled by the institutionalisation of research and development in a country. In Spain, in an environment dominated by public policies strongly aimed at fostering and subsidising or supporting collaboration between public institutions and business organisations, it is not surprising to find that universities and public research centres are the most frequently used collaborating partners. This strong policy orientation has been confirmed by the fact that in Spain around 67% of the firms involved in product development have received public support for what they identify as the most relevant project within the company[7].

With respect to the fact that in Austria more than 70% of government R&D funding is devoted to the higher education sector (the highest percentage in the OECD) it is quite difficult to interpret the relative high co-operation rate with universities and public research institutes in Austria as a consequence of cuts in R&D funding (i.e. that universities are being 'forced' to become more entrepreneurially and commercially oriented). According to Jörg et al (1996) in Austria there are strong co-operation links between some specific university institutes and commercial firms in Austria reflecting personal relationships and initiatives of the firms.

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[7] However, as pointed out by Sanz-Méndez et al (1998) due to the original composition of the data set used for the sampling of the empirical analysis the percentage is highly surprising and lower than expected. (See Technical Annex)

According to Jörg et al (1996) there is also a desire within the university sector for more co-operation and closer relationships.

A common feature for Austria, Denmark and Norway is the strong positive correlation between firm size and collaboration with universities. As pointed out by Schibany (1998) this seems to be an expected result given that larger enterprises tend to employ highly qualified personnel and are more likely to have in-house R&D facilities. Large science-based firms might be better prepared to communicate with universities knowing their codes and their cultures, while smaller firms might have greater difficulties in these respects. In addition, small firms often do not have the personnel and financial resources in order to collaborate with universities.

As in the other countries, suppliers of technological services rank low as foreign collaboration partners. It is interesting to note that in all countries technological services (suppliers of technological services, other private technical consultancies and marketing and management) largely seem to be appropriated in a national setting. A possible explanation could be that at the core of the "products" of knowledge-intensive services lies expert knowledge, problem-solving know-how etc. An inherent problem in "buying" information is the fact that the value of the information is unknown before the actual purchase. Accordingly, the choice of supplier is crucial to what you get. In a business, which is rather opaque, firms might prefer to adhere to national collaboration partners, where additional problems like language barriers, differences in culture etc. are reduced.

5. Model description

Suggested main-author: JLC

Contents:
- introduction
- short description as included

The descriptive statistics above revealed interesting features on inter-firm ccn in the five countries. However, we would like to analyse further the nature of ccn and possible combined effects of variables. Therefore, we develop a model for analysis of the link between collaboration on product development with knowledge institutions and other variables. It should be emphasized strongly that the model has been made according to if the data make analyses possible for all the five countries. This pragmatic model is not the ideal one. A much better model could in practise be made for individual countries or a couple of countries – for example incorporating collaboration intensity, different degrees of innovation intensity etc.

As mentioned we have aggregated the categories universities, consultants etc. and denoted these "Knowledge institutions". This is appropriate in order to have a common reference point and to increase the number of observations. Moreover, our knowledge on university-industry links has increased lately as a consequence of increased interest on this issue. In the estimations of our model we try out different independent variables. Firm size is one such variable. With regard to sector we use both the Pavitt-sectors in this model, and ordinary industry Nace2-classification. We have constructed a variable based on frequencies of partners – that is, if the firm has above or below average number of other collaboration partners. In

addition, we test if collaboration with a foreign partner is associated with collaboration with knowledge inst.

What would we expect? With regard to *firm size* we would expect this to be strongly related to collaboration with knowledge institutions. Reasons for this are pretty straightforward and well-described in the literature: greater knowledge base, more product developments, more employees, more financial resources etc.

Sector of the firm is expected to render results indicating more collaboration within high-tech sectors. In the pavitt-terminology we know from earlier research that this is the specialised suppliers and especially science-based.

One could perhaps expect that firms who have the capacity to collaborate with *above average number of partners* also collaborate with knowledge institutions. Perhaps product development within the group of firms with collaboration with knowledge institutions are more supply driven than other firms? That would most likely demand a range of different partners as inputs to such innovations are often very complex (?). Related to this, if this (speculative?) hypothesis is true, then *suppliers should be relatively more important compared to customers* (customers are generally the most important and frequent partner). An additional explanation why suppliers are expected to be important is that consultants, maintenance etc. are often from suppliers.

If it is true that the knowledge economy is increasingly international, then we would *expect firms who collaborate with knowledge institutions to have at least one foreign partner* (of some kind).

Finally, we would expect the existence of *country* effects mainly due to the institutional set-up in countries to be different.

6. Results from analyses of model

Suggested main-author: Andreas, ALV

The data set as a whole includes 3109 firms from Austria, Denmark and Norway. Out of these 1483 firms have developed new products and 1193 have at some time during a two-year period done it in collaboration with external partners, which is 80% of the product developing firms. 820 have collaborated with knowledge institutions (69%).

Since the variable, collaboration with knowledge institutions takes the value yes/no, categorical data analysis is the most appropriate instead of ordinary least squares models, which best can be applied when the dependent variable is continuos. Since the dependent variable is binary a logistic regression is applied on the 1193 observations.[8] (TO BE EXTENDED)

The results show consistency with the hypotheses above concerning partner and firm specific characteristics.

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[8] Since the dependent variable is binary a logit estimation would have shown the same results.

Firms with an above average propensity to collaborate with other partners are more likely to collaborate with knowledge institutions – 2,67 times more. Thus, the hypothesis that knowledge institutions becomes a bridge to other partners is accepted. One can at this basis put forward a hypothesis that the development of these products may be more supply driven and complex.

There is also evidence concerning firms collaborating with at least one foreign partner. Although the result is weak there is a tendency towards the case that firms who collaborates with at least one foreign partner collaborates more often with knowledge institutions – 1,3 times more. Furthermore, firms who collaborate with customers only collaborates almost twice as often with knowledge institutions while firms who never collaborates with suppliers and customers have a 2,25 propensity to collaborate with knowledge institutions than firms who only collaborates with suppliers. The reason could be that the development of products is supply driven and complex.

The parameter estimates of firm size 10-19 employees, 20-49 employees and 50-99 employees, have negative and significant signs while firms with 100-199 employees are insignificant compared to the reference category of 200 employees or more. The odds ratio indicates that firms with 10-19 employees are almost three (3,24) as less likely to collaborate with knowledge institutions and 20-49 employees 2,35 times less likely and 50-99 employees 1,61 times less likely compared with firms with more than 200 employees. Thus, collaboration with knowledge institutions is positively related to firm size as expected.

The large number of observation in the analysis gives possibility to trace industry differences as expected. Other non-metalic mineral prod., machinery and equipment nec. and electrical and optical equipment industries are all more likely to collaborate with knowledge institutions compared to the food, beverage and tobacco industry which is selected as the reference category. The odds ratios are 2,287, 1,609 and 2,219 respectively. All the other industries are insignificant compared to food, beverage and tobacco. It has to be pointed out that if the industries are divided into Pavitt sectors (results not shown here), then the supplier dominated sector, which is characterised as a low tech sector, only collaborates less than half as frequent compared to firms in the science-based sector.

When it comes to country effects, Austrian firms are less likely to collaborate with knowledge institutions than Norwegian firms while no significant estimates can be traced in the case of Denmark. Norwegian firms collaborate almost twice (1,73) as much than Austrian firms. This effect is mainly due to the institutional set-up and thus the national systems of innovation.

Logistic regression

Dependent variable: collaborated with knowledge institutions yes/no

Independent variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**95.0% C.I.for EXP(B)**	
							Lower	Upper
Prop. to coll. with other part. - under/equal average, **reference:** Above	**-0.983**	**0.187**	**27.64**	**1**	**0**	**0.374**	**0.259**	**0.54**
Not collaborated with a foreign partner, **reference:** at least one foreign	**-0.265**	**0.156**	**2.892**	**1**	**0.089**	**0.768**	**0.566**	**1.041**
Collaborated with suppliers/customers, reference: only suppliers			22.387	3	0			
collaborated with suppliers/customers - no	**0.814**	**0.295**	**7.64**	**1**	**0.006**	**2.258**	**1.267**	**4.023**
collaborated with customers only	**-0.526**	**0.205**	**6.591**	**1**	**0.01**	**0.591**	**0.396**	**0.883**
collaborated with both customers/suppliers	-0.089	0.199	0.199	1	0.656	0.915	0.62	1.351
employees reference: 200 or more			32.871	4	0			
10-19 employees	**-1.177**	**0.234**	**25.398**	**1**	**0**	**0.308**	**0.195**	**0.487**
20-49 employees	**-0.855**	**0.227**	**14.207**	**1**	**0**	**0.425**	**0.273**	**0.663**
50-99 employees	**-0.478**	**0.264**	**3.274**	**1**	**0.07**	**0.62**	**0.369**	**1.041**
100-199 employees	-0.244	0.243	1.005	1	0.316	0.784	0.487	1.262
nacecode - reference: food, beverage and tobacco			23.035	12	0.027			
textiles, wearing appreal leather	0.536	0.354	2.301	1	0.129	1.71	0.855	3.42
Wood and wood products	0.493	0.423	1.358	1	0.244	1.638	0.714	3.756
paper prod., printing and publish	-0.064	0.29	0.048	1	0.826	0.938	0.532	1.655
refined petroleum prod.	3.853	5.951	0.419	1	0.517	47.118	0	5477180.01
chemicals and man-made fibres etc.	-0.03	0.35	0.007	1	0.933	0.971	0.489	1.929
rubber and plastic	-0.292	0.307	0.9	1	0.343	0.747	0.409	1.364
other non-metalic nineral prod.	**0.827**	**0.369**	**5.018**	**1**	**0.025**	**2.287**	**1.109**	**4.718**
processing of basic metals	0.365	0.262	1.936	1	0.164	1.44	0.861	2.408
machinery and equipment nec.	**0.476**	**0.257**	**3.423**	**1**	**0.064**	**1.609**	**0.972**	**2.665**
electrical and optical equipment	**0.797**	**0.294**	**7.375**	**1**	**0.007**	**2.219**	**1.248**	**3.945**
transport equipment	0.419	0.406	1.069	1	0.301	1.521	0.687	3.369
furniture, manufacturing nec.	0.441	0.295	2.236	1	0.135	1.555	0.872	2.774
Country - reference: Norway			8.666	2	0.013			
Denmark	-0.19	0.175	1.18	1	0.277	0.827	0.587	1.165
Austria	**-0.553**	**0.19**	**8.466**	**1**	**0.004**	**0.575**	**0.396**	**0.835**
Constant	1.39	0.47	8.756	1	0.003	4.015		

7. Conclusions

Suggested main-author: JLC, Andreas

Contents:

- implications for our understanding af ccn
- NIS vs. ccn
- Implications for innovation policy:

The results direct our attention towards the role of knowledge-intensive services in the innovation process. The data indicate that *manufacturing firms today are intensively using knowledge-intensive services*. Both the CATI-data and the CIS-type data show that roughly between 30-50% of the surveyed firms had established a co-operative link with consultancy, technological service firms, universities etc.

At the core of the "products" of knowledge-intensive services lies specialised expert knowledge, research and development abilities, problem-solving know-how etc. (Strambach 1997). In this vein, it can be argued, that knowledge intensive services provide a diversity of specialist expertise, which (if the firms succeed in utilising this knowledge) enhances firms' abilities to adjust more rapidly to a continuously changing environment posing new threats and challenges. In prolongation, the knowledge-intensive services can be said to illustrate a high demand for new learning and change within firms and organisations. Further, as revealed in connection with in-depth interviews in the Danish DISKO-survey and as pointed out by Sanz-Ménendez et al. (1998), technological services such as testing and control institutes also play another important role: by acting as external to the firm they provide legitimacy concerning the quality of technological and innovative activities of firms. Thus, factors such as technological skills and legitimacy on technological actions and initiatives place the knowledge-intensive services as major players within the development process.

This points to the need for an industrial policy that gives stronger attention to knowledge intensive services and that proactively encourages the use of these services as a way of enhancing the organisational and technological transformations of firms. Innovation policy must be alert in at least two respects: An inherent problem in buying information is that the value is not known before the purchase. Equally, the choice of supplier is crucial to what the firm actually gets. Needless to say, this choice is very difficult and could be facilitated by government guidance to what specific kind of knowledge the firm can buy from specific suppliers. An important policy task is to increase the transparency of the market for knowledge-intensive services. In prolongation, an important element of encouraging the use of knowledge-intensive services would be to build trust among potential users. As pointed out by Lundvall and Borras (1998), quality control, i.e. instruments and institutions for controlling the quality of knowledge-intensive services, could be a crucial mechanism for achieving this. Another important policy task is to ease the *accessibility* of (especially small- and medium sized) firms to knowledge-intensive services by promoting networks and partnerships actively involving firms and specific knowledge-intensive services for the definition of strategic innovative actions.

References

Arrighetti, A., R. Bachmann, and S. Deakin (1997) 'Contract Law, Social Norms and Interfirm Co-operation', *Cambridge Journal of Economics*, Vol. 21, No. 2.

Burchell, B. and F. Wilkinson (1997) 'Trust, Business Relationships and the Contractual Environment', *Cambridge Journal of Economics*, Vol. 21, No. 2.

Camagni, R.(ed.)(1991): Innovation networks: Spatial perspectives. Belhaven-Pinter. London 1991.

Christensen, J.L. and Rogaczewska, A.P. (1998), "The NSI Project: Synthesis Report of the Focus Group on Innnovative Firm Networks", OECD 1998.

DeBresson, C. et al.(1997): Innovative Activity in the learning Economy - a comparision of systems in 10 OECD Countries. Preliminary draft of report for the OECD Secretariat, presented at the OECD Workshop "National Systems of Innovation and Cathcing up", October 15-16, 1997, Seoul, Korea.

DeBresson, C., (ed.)(1996): Economic interdependence and innovative activity. An input-output analysis. Edward Elgar. Cheltenham 1996.

Dodgson, M. (1996), 'Learning, Trust and Inter-firm Technological Linkages: Some Theoretical Associations', in Coombs, R. et al. (eds.) 1996.

Edquist, C. (ed.) (1997), 'Systems of Innovation: Technologies, Institutions and Organisations", Pinter Publishers. London.

Freeman C. (1982): The economics of industrial innovation. Pinter Publishers, London.

Freeman, C. (1987): Technology and Economic Performance: Lessons from Japan. London, Pinter Publishers.

Freeman, C. (1991), 'Networks of Innovators: a Synthesis of Research Issues', *Research Policy*, Vol. 20, No. 5.

Freeman, C. (1991): Networks of Innovators: a Synthesis of Research Issues, Research Policy, 20, 5.

Freeman, C. (1995), 'The National System of Innovation in Historical Perspective', *Cambridge Journal of Economics*, vol.19, no. 1.

Fölster, S. (1995): Do subsidies to co-operative R&D actually stimulate R&D investment and co-operation? Research Policy, 24, 404 - 417.

Gambetta, P. (1988) Trust: Making and breaking co-operative relations. Oxford: Basil Blackwell.

Geroski, P.A. (1993): Antitrust policy towards co-operative R&D ventures, Oxford Review of Economic Policy, 9, 2.

Hagedoorn, J. and Schakenraad, J. (1992): Leading companies and networks of strategic alliances in information technologies, Research policy, 21.

Håkansson, H. (1989): Corporate Technological Behaviour - Co-operation and Networks. London, Routledge.

Håkansson, H. (ed.) (1987): Industrial Technology Development - a Network Approach. London, Croom Helm.

Jacquemin, A. (1988): Co-operative agreements in R&D and European antitrust policy, European Economic Review, 32.

Jacquemin, A. and Soete, L. (1994): Co-operation in R&D, efficiency and European policy, European Review 2, 1.

Jörg, L., Polt, W. and Pichler, W. (1996), 'The University within the Austrian System of Innovation. Some Empirical Evidence' (in German); Seibersdorf/ Vienna, July 1996.

Kline, S.J. and Rosenberg, N. (1986): An overview of innovation, in National Academy of Engineering: The Positive Sum Game: Harnessing Technology for Economic Growth, The National Academy Press, Washington D.C.

Lam, A. (1998): The social embeddedness of knowledge: Problems of knowledge-sharing and organisational learning in international high-technology ventures. Forthcoming as DRUID Working Paper.

Lane, C. (1997) 'The Social Regulation of Interfirm Relations in Britain and Germany: market rules

Lazaric, N. & Lorenz, E. (1998): Trust and Economic Learning. Edward Elgar.

Lorenz, E. (1998): Trust, Contract, and Economic Cooperation. Cambridge Journal of Economics.

Lundvall, B.-Å. (1988), 'Innovation as an Interactive Process – from User-Producer Interaction to the National System of Innovation", in Dosi, g. et al. (eds): *Technical Change and Economic Theory*, London, Pinters Publishers

Lundvall, B.-Å. (ed.) (1992), 'National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning', Pinter Publishers, London.

Lundvall, B.-Å. and Borrás, S. (1998), ´The Globalising Learning Economy – Implications for Innovation Policy'. OECD

Nelson, R.R. (ed.) (1993), 'National Innovation Systems: A Comparative Analysis', Oxford University Press, Oxford and New York.

OECD (1992): Technology and the Economy - The Key Relationships, OECD, Paris.

Pavitt, K. (1998), 'The Inevitable Limits of EU R&D Funding', paper prepared for the DRUID Summer Conference 1999, June 9-12, Rebild Denmark.

Rosenberg, N. (1972): Technology and American Economic Growth. New York.

Sanz-Menéndez, L., García,C. and Alvarez, I. (1998), ‘ R&D Collaboration Networks in Spain’, NIS/OECD Focus Group on Inter-Firm Collaboration

Schibany, A. (1998), ‘ Co-operative Behaviour of Innovative Firms in Austria. Focus Group: Innovative Firms Networks’, Study prepared for the OECD Project on National Innovation Systems; Seibersdorf/ Vienna, June 1998.

Strambach, S. (1997), ‘Knowledge-intensive Services and Innovation in Germany’ (upublished report), University of Stuttgart.

von Hippel, E. (1993): Sticky information and the locus of problem solving: Implications

Working Group on Innovation and Technology Policy (1997), ‘An Empirical Comparison of National