Studies of Clusters as a Basis for Industrial and Technology Policy in the Danish Economy

by

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Abstract:
The main focus of the paper is on the recent development of clusters defined as "resource areas". The concept has been a cornerstone in the technology and industrial policies laid out from the Danish Ministry of Business and Industry, since 1993. Earlier studies (industrial complexes) identified clusters using transactions, often in an input-output framework, while the present clusters are to a larger degree based upon a demand perspective.

The paper firstly describes and assess the earlier industrial complex studies, and other related case studies of clusters of particular positions of strength in the Danish economy. The industrial complexes and micro-founded studies of Danish clusters, have all been either a direct input, or a reference point when developing the resource areas. However, the most direct influence have been the Danish Porter studies. Denmark participated as one of ten countries in M. E. Porter's analysis of clusters of competitive advantages. Accordingly, the Danish Porter studies are summarised. In continuation hereof, the development of the methodology applied for developing the resource areas, is discussed in a historical perspective. Furthermore, different techniques for identifying industrial clusters are considered, including input-output approaches.

Finally, the paper warns that theoretically based studies and practical policy actions do not always combine easily. Striking a balance between allowing for pragmatic policy making (with more than a single aim) on the one side, while not losing the theoretical foundation on the other, is an important task.

1. Introduction

The purpose of the present paper is to give an overview of cluster studies over Denmark in the last two decades, both as analytical "tools" in their own right, and as the basis for industrial and technology policy measures. The paper is a contribution to the focus group on mapping of clusters under the OECD programme on National Innovation Systems, which is a programme run by the Working Group on Innovation and Technology Policy (TIP).[1]

Cluster studies have in the later years been a corner stone in Danish business and industry policy making, but attempts to identify production clusters can be dated back to the early 1980's. The most recent development in Danish cluster studies is a movement towards identifying innovative clusters at different levels.

The definition, or rather definitions, of a cluster applied in this paper varies according to focus of the study and the level of aggregation, and the paper does not end up with a unique definition of a cluster as a unit of analysis.

In the first studies in the early 1980's, a cluster - an industrial complex - was defined according to supply-and-demand linkages in the production structure. This led to at least four meso-based studies, and three related micro-based studies which focussed on important linkages in sectors in which Denmark is strongly specialised.

Production linkages and, more important, comparable policy framework conditions, were used in delimiting the clusters, which are used in Danish business and industry policy making today: Resource areas. In the most recent attempts to identify innovative clusters, innovation flows are used for identifying clusters at the industry level, while statistical cluster techniques are used for identifying innovative clusters at the firm level.

The main focus of this paper is on the resource areas, their methodological and theoretical foundation, the statistical and methodological problems in identifying the clusters, and on their use in policy formulation and implementation. In relation to the tasks of the overall project, concerning [1)] a national positioning in relation to cluster analysis and cluster related policies, [2)] performing comparative case study work, and [3)] assessing policy implications and policy options, the present paper relates to tasks 1 and 3.

2. The first cluster studies

This section will present cluster studies performed at different levels of analysis. Figure 1 presents an overview of different levels of analysis for cluster studies and their corresponding analytical focus. The subject of section 2.1 is meso level studies of linkages between industries, while section 2.2 identifies clusters at the intersection between the meso and micro level of national strength positions, based on strategic inter-firm linkages.

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[1] Lead country of the focus group is the Netherlands, which is responsible for the preparation of a synthesis paper on the basis of the country contributions and a general methodological paper.

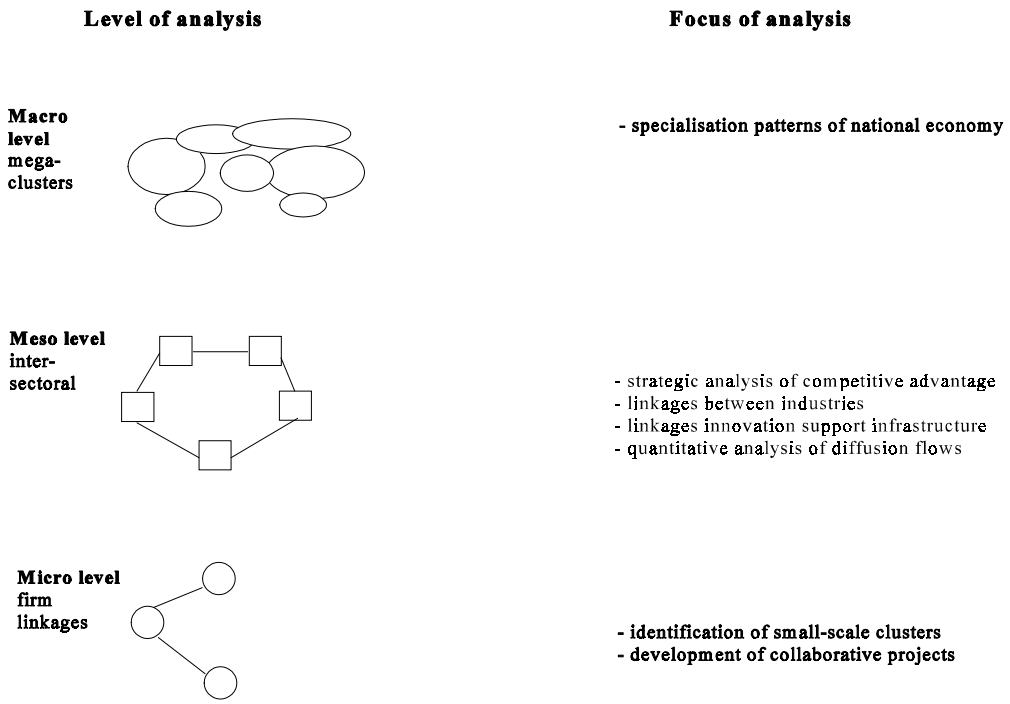

Figure 1: Cluster approaches at different levels of aggregation
Source: Roelandt and den Hertog (1997)

2.1 Industrial Complexes

In the early 1980's a sequence of studies of so-called industrial complexes were carried out in Denmark. The studies were part of a project financed by the Danish Technology Council and were focussed on the development and diffusion of new technology in the Danish economy, and more specifically on how the use of micro electronics influenced central economic variables such as the balance of payments and employment.

The four industrial complexes studied were:

- the agro-industrial complex;
- the textile complex;
- the environmental complex; and
- the office machinery complex.

The main idea behind the concept of industrial complexes and the related concept of "production verticals" (the parts that make up the complexes) is that the linkages between, on the one side, firms developing new technology expressed in components, machines and production systems, and on the other side, firms using this technology, are at the core of the economic system. These linkages are crucial for the development, diffusion and use of new technology. The concept of industrial complexes, defined as a group of industries connected through important flows of goods and services, can be dated back to Lodh and Lewis (1975) and Czamanski and Czamanski (1977), but the theoretic foundation is to be found in Dahmén's (1988) development blocks -

complexes of industrial interrelations - which are to be analysed in terms of the dynamics of the interrelations as they evolve through time.[2] The concept of development blocks belongs to the field of "Schumpeterian dynamics" and is central in industrial economics. *Transformation* is a central factor, focussing on changes in broad aggregates as expressions of underlying changes through time within and between micro-entities. Examples of transformation are (Dahmén, 1988, p. 4):

- introduction of new methods of production and marketing;
- appearance of new markets and marketable products and services;
- opening of new markets;
- exploitation of new sources of raw materials and energy;
- scrapping of 'old' methods of producing and marketing products and services;
- disappearance of 'old' products and services;
- decline and fall of 'old' markets:
- closing of 'old' sources of raw material and energy.

The introduction of micro electronics is related to almost all the above mentioned transformation processes, especially the processes concerning production methods, including the organisation of production, and the development of new products and services. This implies that even though an industrial complex cannot in a narrow sense, be perceived as an innovative cluster, there is an obvious linkage to innovation and new technology trough the focus on technological development in general and the microelectronic development in particular.

The four complexes

The four chosen complexes, which by no means are representative of the total economic system in a statistical sense, each represents different types of relations between producers and users of new technology.

Different methods, all related to vertical linkages between users and producers, were applied in identifying the complexes:

The *agro-industrial complex*, which was subject to the most detailed study, was mainly identified by the use of input-output tables of the national economy. Sectors either receiving a relatively large fraction of their input or delivering a relatively large share of their output to the core sector of the complex (primary agricultural production) are considered as part of the complex. Sectors which are only indirectly connected to the core areas of the complexes are also included (identified by the use of the Leontief inverse input-output matrices). In order to capture the flows of capital goods, by other means than input-output tables have to be included though. The agro-industrial complex was by all means the largest integrated complex in the economy, with a production value of almost the same size as all other manufacturing sectors added together in the observed period. Therefore, production related to agriculture played - and still plays - a major role in the Danish economy, both in terms of consumer and investment products (Lundvall, et al., 1984). The agro-industrial complex also illustrates the importance of the home market for

[2] Dahmén originally introduced the development block concept in his dissertation (1950; 1970).

international trade specialisation. A particular part of the complex is 'the dairy vertical'. An important part of the vertical consists of the linkage between users of dairy equipment (large Danish dairies) and manufacturers of machinery for the use in this sector. In the ISIC nomenclature, dairy export belongs to the food, drink and tobacco sector, whereas dairy equipment is included in non-electrical machinery; two sectors in which Denmark is heavily specialised. Thus, an important part of the knowledge base of these sectors is created in the interaction between the two, thereby resulting in a co-evolution between the sectors, which tends to produce international competitiveness in both fields.

The second complex studied is the *textile complex,* which is defined as the textile producing industry and its main suppliers and users. Even though this also builds on an input-output approach, lack of detail in the aggregation of the input-output tables made it impossible to use the tables in the actual definition of this complex. As opposed to the agro-industrial complex, machinery is almost negligible in the textile complex, which makes the textile complex close to identical with the textile and clothing industry (Thøgersen, 1986).

Lack of statistical data was a major obstacle in the analysis of the *environmental complex*, which was to a large extent based on interviews, in particular with people connected to the area of waste water treatment. The environmental complex was defined as constituting of users and producers of environmental technology as well as intermediates, i.e. actors external to the actual users and producers, who are instrumental in supplying information and advice about new technological opportunities (Gregersen, 1984).

The analysis of *office machinery* is only marginally related to the complex approach. The basis of the analysis was a questionnaire survey regarding electronic data processing and office automatisation in Danish municipalities. The basic difference between the analysis of the three above-mentioned complexes and the analysis of office machinery is, that in the latter case, the focus is on a specific type of users as opposed to a focus on the interdependence between producers and users. The producers are indirectly present in the analysis though, since the office technology used by the municipalities to a large extent consists of systems developed by the public company "Kommunedata" ("Municipality Data"). The fact that both the users and the producers are part of the public sector offers a new perspective on the interdependence between the two types of actors (Brændgaard, et al., 1984).

The analysis of the four complexes, through their variety in focus and method, showed some general characteristics of the technological changes experienced in the different complexes, and some characteristics of the influence of these changes on the Danish employment and competitiveness.

Main results of the industrial complex studies

In the *agro-industrial complex* a major aim was to analyse whether is was possible to identify either the presence or possibility of technological dynamics, crucial for liberating the complex from its vulnerable specialisation in standardised products with a stagnating market. The study concluded that qualified and demanding users had played an important role for the development of new technology, but signs of an increasing inequality in competences between producers and users of new technology, which could have negative effects on production, export and

employment, could be identified. Concerning possible new technological dynamics the bio-technological field was identified as having by far the largest potential with regards to renewal in the agro-industrial complex, not just regarding the supply of innovation from outside the complex, but also in terms of using biotechnology for practical purposes inside the complex in both primary agriculture and processing industries. But new technology by itself is no solution without proper organisational changes, which lead to a recommendation of a strengthened "sector" or "complex policy" aimed at improving the vertical relations between sectors as opposed to specific "microelectronic policies" or "technology policies" (Lundvall, et al., 1984, pp. 126-148).

In the analysis of the *textile complex*, Pasinetti's (1981) production based model of technological dynamics, linking economic growth to structural change, together with the product life cycle theory, are the main theoretical starting points. The main conclusion is that although the complex as a whole seems quite mature with tendencies of "dissolvement" of the linkages in the complex as a result, certain new or emerging product fields could be identified (e.g. carpets), indicating that the interactions could still result in dynamic effects. The technological development has also mainly had the characteristics of a mature set of industries with a clear tendency towards standardisation. New products and processes, created through the interaction between the agents at different levels in the complex, were perceived as needed in order to fight decline in domestic production and employment in the textile complex.[3]

The *environmental complex* differs from the two above mentioned complexes by having the public sector as a main user as well as an important regulator. In this regard the complex study gives new insights to the role of the public sector in the building up and maintenance of national competencies, through its actions as a competent user. But as a complex or cluster study it is atypical.

As mentioned above, the analysis of *office machinery* is only marginally related to the complex approach. Again the public sector is in focus, the theme of the study being the Danish municipalities as users of electronic data processing and office automatisation, and the consequences of this for employment. The main conclusion is that the introduction of office machinery in the municipalities had not been driven by an aim to reduce employment, whereas the possibilities for keeping the introduction of new technology employment-neutral in the future are more uncertain.

Methodological considerations

The above mentioned differences in approach and focus of the industrial complex studies can be considered both a methodological problem and strength. Even though user-producer linkages are the main determinants of an industrial complex, no general way of identifying complexes was developed. In terms of comparability and consistency of definition, this creates problems, but on the other hand, the variety in approaches supplies a complementarity in the facets of the different

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[3] As history has shown, the domestic production, and thus the employment, was not maintained, and if an analysis of the textile complex was to be carried out today, it would not be possible without including the production placed abroad in low-wage countries. The consequences of the moving out of production for the vertical linkages in the complex are not discussed in the present paper.

analyses, which can be of great value when dealing with a relatively new research area. The study of the agro-industrial complex is the most consistent in relation to a cluster approach, and it is also in this study, that the method is most clearly defined and developed. When using input-output data there are some considerable problems though. First of all the level of aggregation is to a large extent given in advance - this is why the input-output method proved to be inadequate in the study of the textile complex - a level which might not be appropriate for identifying the most important user-producer linkages. Another methodological problem is that input-output tables are constructed from the goods level rather than the firm level, i.e. there is no direct relation between input-output sectors and firms. The lack of dynamics in the analysis is also apparent. Finally the studies of industrial complexes are not representative of the Danish economy, but each represents an area which *in isolation* is an interesting object for analysis. The four complexes analysed cannot be perceived as *the* important clusters in the Danish economy though, and as such their value lies in the thoroughness of each individual study rather than in the combination of all four studies.

2.2 Micro-based cluster studies[4]

Related studies of important linkages facilitating distribution of knowledge within the innovation system, were carried out at the micro-level, in three different sectors in which Denmark is strongly specialised (see Dalum, 1996). This section serves the purpose of illustrating the differentiated nature of the knowledge base in manufacturing, and in this context the differentiated importance of the specific knowledge across sectors. The section will briefly describe the creation and distribution of knowledge in a specialised supplier sector (electro-medical instruments), a supplier dominated sector (furniture), and a science-based sector (pharmaceuticals).

Electro-medical instruments

The ISIC sector *instruments*, is one in which Denmark is specialised in terms of R&D expenditure and where Denmark has a relatively high R&D intensity as compared to a selected group of OECD countries.[5] Lotz (1990) demonstrates the historical importance of the interaction between medical instruments and an advanced domestic hospital sector. One example of the importance of the interaction is the most successful Danish firms in this area, namely Radiometer, where internal R&D conducted since 1935 has provided a basis for a close interaction with Danish hospitals, especially Rigshospitalet (the State University Hospital) in Copenhagen. Thus, one of the major innovations (apparatus for measuring the level of pCO2 in the blood) for this company was actually invented by a head of department of clinical chemistry at Rigshospitalet in the early fifties, but transformed into an innovation at Radiometer. Today, the interaction with hospitals (especially in the Copenhagen area) continues, in order to maintain competitiveness by means of distributing user-knowledge from hospitals to specialised suppliers in the instrument sector.

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4 This section draws on Laursen and Christensen (1996).

5 This group includes Canada, Germany, Denmark, Finland, France, Great Britain, Italy, Japan and USA, and is hereby referred to as the OECD9.

Furniture

Wood, cork and furniture, is another sector where Denmark is specialised in terms of value added, but with a lower level of R&D intensity, compared to the OECD9. In other words, the sector seems to be competitive, although it has a comparatively low R&D intensity.This apparent paradox is explored by Maskell (1996). The wooden furniture production consists of two distinctive and technologically distinct processes - the process of manufacturing the furniture (wood cutting, drilling, shaping, grinding and shaping), and the process of painting it (the entire coating process including smoothing, painting or lacquering, priming, drying/defueming, polishing etc.). The exchange (distribution) of knowledge is not conducted by means of the development of capital equipment for the former process, since today 90% of the machinery is imported, mainly from Germany and Italy. The same goes for the machinery for painting (mainly imported from Italy). But while the industry works with more or less given process technologies, a part of the manufacturing process can be 'moulded' or adapted as to give a leading edge. This part of the manufacturing process includes lacquer and paints, which is adapted in the interaction with domestic manufacturers. Another important contribution to the knowledge-base comes from an *agglomeration effect*, and reflects that local and specialised educational institutions play an important role, together with the (local) mobility in the labour market.

Pharmaceuticals

One of the few science-based sectors strongly present in Denmark is the pharmaceutical sector. In terms of growth in Danish share of OECD9 R&D from 1980 to 1991, the pharmaceuticals sector accounted for nearly 50% of the total Danish growth, and from a more static point of view the sector accounted for as much as 24% of total Danish R&D in 1991. By far the largest Danish producer in this sector is the worlds largest manufacturer of insulin for diabetics Novo Nordisk (Laursen, 1996). The company's history goes back to early this century. From a historical point of view, it is remarkable that the breakthroughs in terms of new and radically better insulin products have been conducted inside the firms R&D department, although often in collaboration with foreign scientists (mainly American). Thus, largely firm-specific knowledge has been accumulated over nearly 3/4 of century, where the technological linkages (dynamic synergy effects) between different products have been an essential feature. Nevertheless, one has to point out the importance of the presence of a strong national science-base. A particularly strong Danish science-base can be identified, in this context, if measured by number of published papers per capita in life-sciences, where the number of papers published was about 20% higher than the US figure, and about 70% higher than an EU10 average in the period 1981-1986. But Denmark ranks high generally speaking, in all of the major science fields in addition to life-sciences (mathematics, physical sciences, engineering and chemistry), both in terms of papers per citizen, and measured as mean citation per paper.

Even though basic research tends to become globally accessible, since it has a strong public good element, this is not the full agenda. Recent research by Hicks *et al.* (1994) has showed that publications produced by Japanese companies (basic research) tend to over-cite the national science system by approximately 30%, which in turn suggests that the economic benefits are geographically and linguistically localised, since they are embodied in persons and institutions, and thus mainly transmitted through personal contacts. Similar findings have been made by Narin and Olivastro (1992) showing that national patents cite national science and vice-versa. A strong

position in basic research is therefore economically important at the national level, because it provides research training, state-of-the-art development and use of research techniques and instrumentation, and access to high-quality international networks (Gibbons and Johnston, 1974;Pavitt, 1993). In addition, basic research provides an important country-specific resource to science-based firms, providing recent results from national as well as international state-of-the-art-research as an input to commercial research. These benefits accrue, not only because of the research conducted by the scientists of a given country, but (mainly; at least in a small country case) because of the increased ability to assimilate results of basic research conducted by other countries, an ability which in turn partly depends on the home country's ability to perform high quality basic research itself. In the Novo Nordisk case major break-throughs were nearly always taking place at foreign universities. In this context, the *research skills*, developed at Danish universities, have been of utmost importance in assimilating and commercialising inventions made abroad. In the context of *state-of-the-art development and use of research techniques and instrumentation*, comprehensive mathematical molecular models should be mentioned. Another potential impact of basic research was found in many cases through the entire history of Novo, namely the *ready access to high-quality international scientific networks*, a story which began with Nobel Prize winner and originator of insulin production in Denmark, August Krogh in 1923, ending up with current contacts to 'centres of excellence' in biotechnology, situated in California.

Thus, a continued commitment to basic research is of central importance to the competitiveness of this sector. So far, little research has been conducted applying (at a detailed level) bibliometric methods, in order to access the continued viability of the science-base in the Danish system.

The knowledge bases

This section has shown that the sources of technology differ between different development blocks . Table 1 illuminates some of these differences, and serves to illustrate that the important knowledge base of sectors in a system may well reside in the interaction with other parts of the system.

Smith (1995) distinguishes between three different areas of production relevant knowledge related to different levels of specificity. The *first* level is the *general scientific knowledge base*, which consists of very differentiated fields of knowledge with a widely varying relevance for industrial production. The fields with the closest connections with major industrial sectors are to be found within areas such as molecular biology, physics, genetics and inorganic chemistry. The *second* level is the knowledge bases at the level of the *industry or product-field*. At this level industries' often share particular scientific and technological parameters, and with industries intellectual understandings concerning technical functions, performance characteristics, the use of materials etc. are shared. The *third* level concerns the knowledge bases of *particular firms*. At this level we are dealing with only one or a few technologies, which are well integrated into the firms and form the basis of their competitive position. Due to the high level of specificity of technology at this level, there are clear limits of the firms' competences. Thus, the firms must be able to access and use knowledge from outside the core area of the firm.

A characteristic feature of the three levels is, that the level of specificity, as well as the intangible elements of the knowledge base, decreases when the level of aggregation increases. In the studies presented in section 2.1 and this section 2.2, we are primarily dealing with industry and product-

Table 1: The most important knowledge bases for three particularly strong Danish sectors

Sector	Important external knowledge bases (interaction with)	Level of cumulativeness in R&D	Importance of scientific knowledge	Importance of technological service systems
Furniture	Domestic producers of laquer and paint	low	low	some
Medical instruments	Domestic hospitals	high	some	-
Pharmaceuticals	National and international science-bases	high	high	-

field related knowledge bases, but as e.g. exemplified in the study of pharmaceuticals above, also the national science base (level one) and the combination of firm specific and external knowledge (level three) are included, i.e. all levels of knowledge are relevant at each level of analysis, but in different "proportions".

As was shown in this and the preceding section, the interaction or interdependence plays an important role in defining a cluster, both within and between industrial sectors. The next section will show, that this thought has survived in more recent policy oriented industrial cluster studies. The industrial complexes can be perceived as the "forerunners" of the resource areas introduced by the Danish Ministry of Business and Industry in 1993. The fact that the agro-industrial complex was the most consistent is underlined by the survival or rather revival of the complex as a "Food Products Resource Area". The other complexes studied are all part of larger resource areas.[6]

3. The Danish Porter Studies and the Resource Areas[7]

The industrial complexes and micro-founded studies of Danish clusters mentioned in section 2, have all been either a direct input, or a reference point when developing the resource areas. However, the most direct influence is the Danish Porter studies. Denmark participated as one of ten countries in M. E. Porter's analysis of clusters of competitive advantages. The studies were later used as the empirical foundation for the theory presented in Porters 1990-book "The Competitive Advantages of Nations". In the context of Porter's book it is interesting that the part of Porter's analytical framework concerning "demand conditions" (see below, for a description) was inspired - among other studies - by a study (see Porter, 1990, p. 86) in the context of international trade, of the previously discussed Danish agro-industrial complex (Andersen, et al., 1981). The Danish Porter studies have been the foundation for the resource areas in two ways: *first* the ideas behind and methodology used in the resource areas are highly related to the Porter

6 Textiles are mainly part of the "Consumer Goods/Leisure Resource Area"; environment is mainly relevant to the "Transport/Utilities Resource Area"; while office machinery is placed in the "Communications Resource Area".

7 We thank Birgit Kjølbye and Mette Kaa Hansen from The Danish Ministry of Business and Industry, and Britta Vegeberg from The Danish Agency for Development of Trade and Industry for useful discussions and comments in relation to this section.

studies, and *second*, and perhaps more important, some of the key researchers and consultants, working on the Porter studies, later worked with or advised on the resource areas.

3.1 The Porter Studies

Denmark was one of the ten countries in which the Porter studies of competitive advantages were conducted.[8] M. E. Porter, who had gained widespread recognition for his work on competitive advantages and firm strategy, was engaged in consulting the US Authorities on growth and competitiveness. In relation to these issues Porter found that we are asking the wrong questions and that we therefore get the wrong answers (Porter, 1990, p. 3). Until the mid 1980's, industrial and trade policy had mainly considered macro and factor conditions in a Heckscher-Ohlin tradition in the US. Porter argued that it was not countries or industries in different countries that competed, but firms. Therefore the focus of analysis had to be on firms. Further, the trade specialisation could not be explained satisfactory by factor conditions, and neither could the fact that there seemed to be clusters of successful firms in particular regions. Porter initiated a study in ten countries (including Denmark) where ten or more industries in each country were analysed. The qualitative analysis focussed on the upstream and downstream value chain relations of the firms, the institutional setting, the firm's surroundings and the firm itself. The theoretical approach was to employ "the diamond" (see figure 1 below) developed by Porter in earlier works. Furthermore, the analysis should have a historical angle since "path dependency"often is important in explaining why a region or country hosts a particular set of firms working in the same sector.

A salient feature of Porters analysis is that it focuses on a broad set of factors influencing the competitive advantage of nations, rather than solely focussing on a particular explanation. However, the approach has been target of criticism, emphasising that the connections between the level of the industry and the level of the nation is unclear, when Porter draws his conclusions. Thus, Porter actually tries to answer some of the "wrong questions" he initially warns us about (Dalum, 1992).

The Porter Methodology - The Diamond

Since the Porter Diamond of factors influencing competitiveness is central not only to the Danish Porter studies, but also to the later resource area analysis and understanding, the central ideas in the Diamond will shortly be presented here.

Innovation plays a crucial role in Porter's understanding of a firm's competitive advantages, both product and process innovations are central in creating new markets or gaining and sustaining market shares. A central observation for Porter is that there seems to be clusters of firms in a country or a region "doing well" in the same business. Chemistry in Germany, pharmaceuticals in Switzerland, semi-conductors in the USA and later Japan, and mobile phones in Scandinavia are just some of the many examples of this type of clustering.

The home base, where the firms are allocating the bulk of their resources to R&D, is seen as

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[8] The other countries were Germany, Italy, Japan, Korea, Singapore, Sweden, Switzerland, United Kingdom and United States.

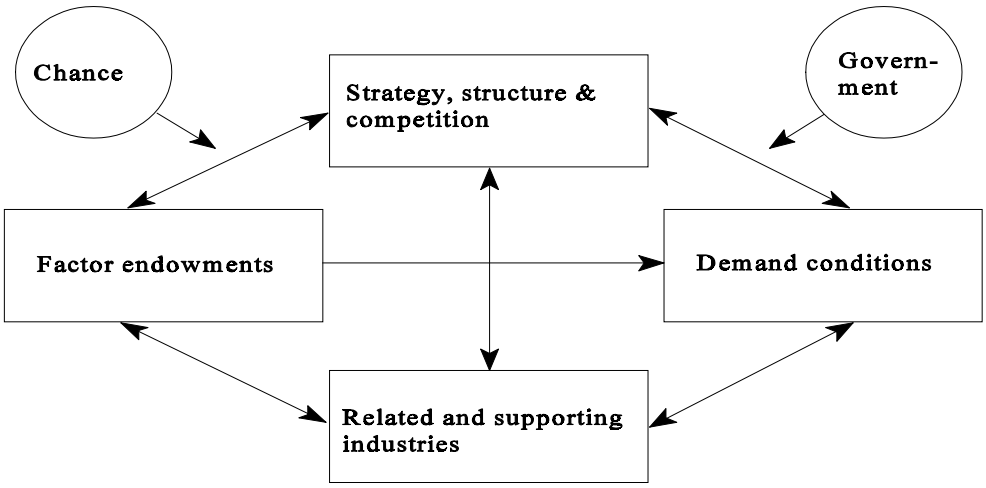

Figure 2: Porter's diamond
Source: Porter (1990)

central to the firms' competitiveness. This in turn implies that it is not enough to analyse the firm alone, in order to explain the firm's competitiveness. Further, it is argued that it is crucial for economic growth that a nation is an attractive home base. The question then is why and how regions have developed to be centres of excellence in a particular industry. If an understanding of the processes behind these developments can be created, this can give a hint as to how to create these centres in the future. Creation of attractive home bases or centres of excellence is to be the goal for industry and business policies.

The diamond which is basically a model of relations and interactions, is used as the analytical tool in the analyses of the interactions between the firm and its surroundings. The diamond consists of six central parts, which can describe the interactions and relations.

1. The firm: The *strategy* of the firm, together with the management of the firm, and the organisation and routines of the firm, are of course important, since in the end it is the firm that must gather and use the knowledge, and the factors of production, in an effective way.

2. The sector: The formal and informal co-operation, as well as the rivalry between firms in the sector is important. Also the strength of the organisations and institutions, which undertake the interests of the sector as a whole are important. The importance can vary, e.g. in some cases rivalry between two firms can be important determinants, while in other cases co-operation can be important.

3. The related sectors:
The presence or lack of presence of related sectors that are internationally competitive, and either supplying or adopting technology in a way that stimulate a cumulative and interactive process, have an influence. This is related to the product and process innovations where lead users or producers of knowledge are seen as important.

4. The home market:
The relative size of the home market and the quality of the demand plays a crucial

role. In sectors with increasing returns to scale a historical large home market can be an advantage. In relation to the fact that not only quantity but also the quality of demand is important in relation to the home market, the public sector can in particular play a central role.

5. The factor advantages:
The factors are both traditional factor endowments but also the infrastructure, the human resources and the technological ability of the country. Usually natural resources have been the sole factors, and the differences in factor endowments in countries have been used to analyse and explain trade patterns. These have proven to not be sufficient and can not explain e.g. the "Japanese miracle". Here factors are perceived in a much broader sense and relates to infrastructure, roads, electricity, information systems etc. Also the human resources, the knowledge, education and socialisation are important factors. Many of these factor conditions are highly influenced by the policies of the state.

6. The state: Regulations related to sectors or business in general. The state's investments in e.g. infrastructure or other investments. Also the state's role as an advanced user is central. In general the state is setting the boundaries for the factor advantages or conditions. Laws related to e.g. standards, patents, anti trust and so on are crucial. Further the state's allocation of resources to science and education are highly important.

These very broad elements are the focus of analysis and it is the interplay between all elements of the diamond that determines the competitive advantages or disadvantages. As mentioned earlier, history matters and many of the clusters we see today, have been initiated and developed through long periods. This implies that cumulative processes have a strong influence, but also that advantages take a long time to build. This is true even if the answers as to how to build these advantages are known a priori.

Porter initiated, as mentioned above, studies in at least ten sectors in ten different countries, using the diamond in a qualitative and historical analysis of each sector in each country. From these studies Porter hoped to find some patterns of how the different interplays and developments in different sectors in some cases gave rise to competitive advantages to firms in these particular sectors or clusters.

3.2 The Danish Studies

The Danish Porter studies were carried out by a consortium of researchers from various universities and business schools together with several private consultants. The work on clusters in Denmark, employing the Porter analysis and theory, was carried out from 1987 to 1991, and was finally reported by Pade (1991). This was preceded by a central publication by Møller and Pade (1988) (on industrial success and competitive factors in nine Danish sectors).

In the Danish Porter project 15 sectors were analysed using the Porter methodology and the diamond as an analytical tool. These sectors were:

- the dairy sector;
- slaughterhouses;
- mink producers;
- the consumer fish industry;
- agricultural machinery industry;
- the biotech industry;
- the pharmaceutical industry;
- electro-medico equipment;
- telecommunication;
- engineering;
- the environmental industry;
- furniture;
- shipping (sea);
- cleaning services;
- mobile phone industry.

On the basis of these sector studies, five clusters with a high competitive ability were identified:

- the agro-food cluster;
- the shipping cluster;
- the technical cluster;
- the pharmaceutical/biotech and medico cluster;
- the mink cluster.

(For methodology and results see Pade, 1991 or Porter, 1990).

In general the rather extensive analysis pointed towards different strengths and weaknesses in the clusters and in Danish industry in general. The relatively small home market was seen as a problem, together with the general small firm size in Denmark. The market size hampered the competition between large rivals, and the small firms had problems in reaching export markets. The small firms gave on the other hand flexibility and dynamics. The relatively high quality of the workforce was a strength, together with a relatively good infrastructure. Furthermore the state in some instances had been able to procure innovations.

The studies and the results gave rise to a very intense discussion on the competitiveness and dynamics of Danish firms, and also on the policies to support development. But also the more fundamental question of what industrial policies actually are, became a hot and widely discussed topic in Denmark.

3.3 The Danish Resource Areas

The Danish Business Development Council (Erhvervsudviklingsrådet - EUR), which has the assignment of advising the Danish government on business policies, took up the idea of clusters as a new perspective on business policies, and initiated the analysis of the resource areas in Denmark. Since the Porter studies there had been ongoing analyses of clusters, areas or blocks in several Danish ministries and agencies. Especially the Danish Agency for Development of Trade and Industry (Erhvervsfremme Styrelsen) had carried out several studies. Also the Danish

Ministry of Finance carried out studies of the Danish industry employing a cluster terminology. In 1992 the Ministry of Finance presented an analysis of "blocks", where they showed that the four blocks they analysed, were responsible for 60% of the Danish export, and in general were highly important in the Danish economy. The four blocks analysed were: the *agri/food*-, the *construction*-, the *naval*- and the *health*-block. In the later resource areas these four blocks are carried on in four of the total eight areas. In a sense the initiation of the resource areas was the outcome of a cumulative process, where the results from the Danish Porter studies, and the Porter way of thinking industry policy, played a central role.

A Theoretical and Analytical Approach to the Resource Area Studies

In one sense the methodological and theoretical foundation of the resource area is the same as in the Porter studies. The Porter diamond was the theoretical cornerstone in the analysis of the relations and interplay in the resource areas, and the methodology to analyse the connections and flows was qualitative with a historical perspective.

The Danish Business Development Council (EUR), trough consulting people who had participated in the Porter studies, identified eight resource areas and a residual area labelled "General Suppliers". The division into these eight areas and the residual area was made from dialogues in the EUR, with reference to the Porter studies and other related studies made by or for the agencies or ministries.

There are some points though where the methodology differs from the Porter studies and cluster studies in general. *First,* it was decided that all Danish industry should be a part of the eight areas or the residual, though not incorporating the public sector. In the Porter studies around 40% of all Danish firms were represented in the clusters. In other words the resource areas have a wider scope than the Porter clusters and clusters in general.[9] *Second,* where the Porter clusters all were defined by their coherency in interaction, some of the resource areas were also seen as clusters since they had the same demand side. In these areas the demand and the demand structure was the common denominator. Thus, it is explicitly stated that the deviation from earlier industry divisions lies in the focus on the end product. *Third,* often when cluster analysis is employed, some factors or variables are chosen in order to identify the possible clusters. This was not the case with the analysis of the resource areas, which was relatively fixed from the beginning.

The eight original resource areas were:

- service;
- agro/food;
- construction;
- environment/energy;
- transport/communication;
- medico/health;
- consumer goods;
- tourism/ leisure.

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9 The effort to include all of industry into the eight areas resulted in a problem with overlaps between most areas.

The residual "general suppliers" could not be placed with reason in any single area. Analyses were carried out in all of the eight areas by different groups of researchers and consultants. These analyses were all published and used as the foundation for the further work on the resource areas.

Besides these qualitative analyses, a statistical group was established to produce statistics for the eight areas. The statistics where on e.g. the area's size, growth, employment, import, export and so on. In order to make these statistics, several special data runs where carried out on the Danish ISIC code at the 6 digit level. This was done in order to aggregate the resource areas, which cut across the standard statistical aggregation. The work was carried out in a rather detailed manner, e.g. several firms were moved from one sector to another, and in many cases a key was made to divide a firm's input and output into the different areas. It is important to stress that it is the firm, that is the unit of analysis, not the flow of goods between firms or sectors.

The actual work method which is employed concerning the resource areas will be described below. In the daily work there is an ongoing development of the methodology and of the understanding of the areas. There has been made several analyses of these areas: some of these are international comparisons which we will turn to later in this paper; but foremost there is an ongoing and intense dialogue with representatives of firms, organizations and public institutions and ministries. This work has, besides resulting in several policy suggestions, also been used to develop and redefine the resource areas. In the following we address this new definition of the resource areas.

The Resource Areas as They are Defined Today

The six resource areas, as they are defined today, are listed below with a description of the changes from the original eight area definition. Further we touch upon the relation to other cluster analysis. Before listing the resource areas, the definition of a resource area, which was constructed in the process of changing from eight to six resource areas, is presented:

- A resource area is a broad range of products or services, which is relatively stable over time and has a considerable weight or size in the economy.

- A resource area is made up of sectors that are mutually interdependent or are in a common relation due to the requirements to produce the final product or service in co-operation.

- The firms in a resource area have the same needs in terms of factor conditions.

- There is one or more position of strength measured by trade performance in a resource area.

This is the official definition of a resource area, and employing this definition, the six areas as well as the general supplier area are now as follows:

- *Food.* This resource area covers agriculture, fishery, dairy, slaughterhouses, production of agricultural machines, fishing boat yards, dairy factories as well as supplies to these,

like cooling machinery, thermostats and so on. This area as defined today is very similar to the agro-industrial complex described in section 2.1. In relation to the Porter studies it contains four of the sectors/clusters found to be internationally competitive clusters .

- *Consumer goods and leisure*. This resource area covers e.g. production of clothing, production of electrical equipment, production of furniture, hotels and bedding, culture, retailing and so on. Here we find the furniture cluster, which also was found in the Porter studies and in the micro-based studies of particularly strong Danish sectors.

- *Construction/Housing*, covering construction, construction engineering, construction materials, retail of construction materials, entrepreneurial companies, crafts related to construction, cleaning, housing administration. Here we find the cleaning cluster found in the Porter studies.

- *Communication*, including printing, printing machinery, media and communication equipment, media, mail and telecommunication, communication services, retail of communication equipment etc. Here we find the mobile phone industry/cluster also identified both in the Porter analysis and by Dalum (1995).

- *Transport and supplying industries*, covering shipyards, production of other transport machinery, energy equipment producers and suppliers, automobile services, road/sea/air/railway transportation, heating/electrical/gas supply, retail and trade with fuel and trash, environmental equipment producers and suppliers etc. Here we find the environmental sector identified in the Porter studies, and the environmental complex found in the industrial complex study.

- *Medico/health*, covering pharmaceuticals, medico technique and aid as well as pharmacies. Here we find the pharmaceutical sector and the medico-technical sector identified in the Porter analysis.

- *General supplier businesses*, which is an aggregation of sectors producing and supplying goods that either are so general in nature, that they cannot be asserted to one area, or they produce highly special equipment to several sectors in different resource areas. These general suppliers includes metal industry, other production industry operational services, consultancy and retail.

There were several reasons for the redefinition, but we present only some of these in the following. In the new areas the public sector is incorporated, which was not the case before. In some of the areas the public produced goods are vital parts of the area and they are now drawn into the areas. As can be seen from the above listing of the new areas, service is no longer a separate area. This is because the service sector was very heterogeneous, and in most cases actually provided services that are closely related to all other areas.

Another visible change is that communication is now an area of its own, where it before was a part of telecom/transport. This change is also the outcome of the many studies and the intense dialogue with key persons. First, it was found that a combination of communication and transportation do not function coherently. Second, it was evident that communication was

growing fast in volume as well as in importance.

Further, the generation of statistics that enabled an analysis of the resource areas over time, which could be used to analyse the resource areas in an international context, was an important issue in the Ministry of Business and Industry. The previous statistics were generated on the basis of ISIC codes, which are not today a common international standard. Therefore the basis for aggregation is now NACE codes (the level from which the areas are aggregated is the four digit NACE code). In the original work on the statistics, quite some resources were used on actually moving some firms from one sector to another, and to make keys dividing the output and input from some firms and sectors into different resource areas. With the new aggregation this is no longer done, which means that a four digit level NACE sector is in its full placed in one single resource area. Employing this method of course brings about some problems in relation to the reliability of the statistics, which we shall return to below. With the statistics it is now possible to follow the development of the resource areas. Further it is now possible to compare the resource areas in Denmark with areas defined in the same way in other countries. A full comparison of all the six areas and the residual is not the intention, as this makes little sense, but e.g. a comparison of the food areas in Denmark and the Netherlands can be used as a benchmark exercise, since both countries are specialised in food, and have possible similarities.

The Working Method in the Resource Areas

The focus and scope in this position paper is on the applied methodology, and to further develop the methodology and the ideas behind and the resource areas. In the daily work this is of course not the main aim for the Ministry of Business and Industry. The resource areas, and the applied working method and analysis, are first of all aimed at creating policies and identifying problems, future threats and strengths for the firms, which in turn leads to new policy initiatives. This is important to bear in mind, especially when discussing the methodology in relation to the focus and scope for the present paper. Still it is the knowledge created in the daily work that is used to develop the resource areas. In the following we shortly describe the work methods within the resource area framework.

In relation to each of the resource areas there is a constituted reference group. The Ministry of Business and Industry has invited representatives from firms, organizations and related ministries to participate in these reference groups. The reference groups are stable over time, and are in a sense the focal point in the work. On the basis of the dialogue and the various analyses, the reference groups points towards critical policy conditions. The policy conditions in some cases need to be analysed and discussed further in order to come up with actual policy initiatives. This further analysis and dialogue is carried out in work groups that are constituted around these specific tasks. The ideas and initiatives from the working groups are then fed into the political process. In principle the initiatives are brought into the political process by the representatives, ministries or organizations that seems to be best at supporting the initiatives. The working groups are then terminated since they are working *ad hoc*, related to specific tasks.

A vital part in the work on the resource areas is that it is kept public, so that anyone with an interest can contribute to or follow the work. The core of the work is always the problems or the wishes of the firms in the resource areas, and it is emphasised that firm employees and organizational representatives directly participate in reference groups as well as working groups.

Quite a few of the critical conditions and policy initiatives are also related to resorts traditionally undertaken by other ministries than the Ministry of Business and Industry, e.g. the Ministry of Research, the Ministry of Education or the Ministry of Employment. This calls for a stronger focus on co-ordination between the different ministries, and often officials from other ministries are key persons and in some cases board the workgroups.

In February 1997 a status rapport was made on the work on and the outcome of the resource areas. This illustrates that since the resource areas were introduced, 29 working groups have been initiated, of which 22 have completed their work, and 7 are still working. In these groups 513 people from firms, organizations, institutions and the ministries have been involved. The dialogues in the workgroups have lead to 152 suggestions or initiatives, of which 66 were implemented , either completely or partly. The initiatives covers a broad range of initiatives of which some could be carried trough without changing laws, some called for change in laws or administration, and again some initiatives influenced the fiscal budgets of ministries.

There are ongoing attempts to develop the theoretical foundation and the understanding of the resource areas, since the dialogue and the various analyses of problems and critical policy conditions are also used to develop the resource areas. As previously mentioned, some comparative analyses of policies, institutions and interactions have been employed on other countries.[10] Often the countries are chosen because of their strength in specific areas, or since some policy initiatives are thought to be of specific importance. The policy initiatives in the analysed countries are also used as an input to the process of figuring out how to set up policies aimed at a specific area. In general the studies are studies of best practice or benchmark studies.

An example of such an comparative analysis is carried out in the food resource area, concerning the policies and conditions related to biotechnology. The development, knowledge and use of biotechnology was identified as important for the future development in the food resource area (this was, as mentioned in section 2.1, already foreseen in the complex study). The comparative analysis of policies and conditions was carried in the United Kingdom, Germany, the Netherlands and United States. The analysis was explicitly focussed on the conditions given by regulations in order to benchmark these conditions. The qualitative analysis was based on interviews with key persons in the respective countries. A very short summery of the outcome of the comparisons lead to the recommendation that:

- It is imperative that there is a public understanding of biotechnology. This is to be supported by a multi faceted public information and debate.

- The regulations related to the use and test of biotechnology are critical in the development of the field, and in the protection of the consumers. Here a specific recommendation was

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[10] International studies have also been carried out outside the auspices of the Danish Ministry of Business and Industry. An example of this is NUTEK (1995), which compares experiences of cluster studies and related industry policies in Denmark, Finland, the Netherlands and Norway. The experiences are used in a discussion of whether, and if so, how a Swedish cluster analysis should be carried out. The Danish model is emphasized because of the inclusion of all of industry, in stead of focussing on industries with a particular strength position with regard to trade specialisation, as well as the large degree of policy relevance.

that common regulations are established in the EU countries.

- Research is the vital input to the field, and this should be strengthened in Denmark. Both by allocating more resources but also by co-ordination the research. Further it is proposed that the research in strong, already existing, research environments is supported.

A Discussion of Methodology

In a discussion of the strengths and weaknesses of the methodology used in the analysis of resource areas it is important to notice that many different methodologies are employed. The most central method used in the initial analysis was the qualitative and historical studies of the development and interaction in the respective resource areas. Another methodology that is often used in relation to the resource areas, is to measure positions of strength. Positions of strength are based on trade specialisation, and the general idea behind the method is to use a Balassa index (see Balassa, 1965) to determine in which sectors a trade specialisation can be found. To sum up the dialogue with key persons is central together with comparative analyses, and in addition to this there is the statistical exercise which is used as a yard stick.

In the following the methodology discussion will:

- relate to the initial division of the eight areas and the re-division into six areas;
- discuss the strengths and weaknesses in the qualitative approach;
- discuss the strengths and weaknesses in the statistical exercise;
- discuss weather or not other methods can contribute to the currently applied methodologies.

As previously mentioned the resource areas, in their present form, covers the entire Danish economy which is divided into six areas and a residual area. Initially there were eight areas and a residual. In the definition of an area the coherency, the interdependence and the need for common policy conditions are stressed as factors delimiting a resource area. When we look at other studies made on clusters in Denmark and in other countries, the scope of a resource area is considerably wider. During the process, both related to the initial division, but also in connection to the redefinition, the resource areas have been criticised for including more clusters within a single resource area, which has led to a situation where the coherency in some areas can be questioned. Second, because of the broad scope, it is questionable whether the interdependencies between firms and sectors in a resource area are all equally outspoken and important.

When we turn to the qualitative and historical studies of the relations in a resource area, the strengths are that most of the relations are intangible in the sense that they are hard to measure statistically. Many important relations will not show in statistics on firm level or in input-output tables. Especially when a cluster, as in the Porter and resource area tradition, is understood as a highly complex interaction of several factors, causal relations cannot be measured; only the ex post outcome of the relations can be measured. Therefore qualitative interviews are perhaps the

only way to bring about information on possible causal relations. In that context especially the comparative studies are very useful since the importance of factors are more easily determined in the comparisons. The weakness is of course that in a complex world other factors than the ones stressed could be important, and often qualitative analysis is criticised for subjectivity due to the fact that the issues at hand cannot be measured.

The generated statistics and the methods used to generate statistics have pro and cons. The benefits are that it is now possible to make time series comparisons and international comparisons across areas. The weakness lies in the fact that the method employed cannot capture all the dynamics in the areas, and especially across the areas. Further, there is a possibility that when four digit level NACE sectors are aggregated into the six (plus one) areas, there are some "failures" in measurements of the areas. Some firms and many sectors deliver to different areas, but are only measured in one. Also very product diversified firms are only considered in one area. The decisions of which sectors belong to which resource areas have never been empirically tested, and therefore the coherency and their placement can be questioned. However, by using firm statistics and not e.g. the input-output tables, the analysis can be made on a more disaggregated level. This is important since the resource areas and clusters in a Porter sense does cut across the traditional sector aggregations.

In the context of resource areas there has seemingly never been conducted input-output analyses to supplement the other methods employed. Denmark has relatively dis-aggregated input-output tables (117 sectors). The cons are as mentioned above that input-output tables measures relations as flow of goods and services. In other words only the tangible relations are included, since any relation or interaction that is not an economic transaction is not measured. With the use of input-output analysis it is possible to determine whether the transactional relation, which is argued to exist in the different resource areas, is actually present. One could argue that if the 117 sectors were aggregated into the 6 resource areas, they should have a relatively high internal flow of goods, if the value chain perspective is employed.

An analysis of inputs and outputs in the 117 sectors can be used to empirically test the placing of an sector in a specific resource area. Input-output analysis could then be applied to make keys dividing in/output from one sector into the respective areas, by measuring the path of its outputs. Since it is the flow of goods or transactions that is measured, one can make a dynamic analysis which also can be used to identify upcoming clusters. Further, when input-output tables are merged with data on e.g. education, public and private R&D and patent statistics, it is possible to measure the importance of knowledge flows, though these methods of course do not measure all forms of knowledge.

4. Ongoing Studies of Innovative Clusters

The above presented different types of cluster studies are all primarily concerned with identifying industrial production clusters. The relations studied are first of all supply and demand oriented, and dynamic features of the relations are secondary to the analysis. Ongoing research carried out in relation to the Business Development Council-financed DISKO project (a study of the Danish innovation system in a comparative perspective) has its main focus on innovation-related interdependencies.

Ongoing work on identifying technological and innovative clusters at the industry level is applying a variety of methods, resulting in different types of clusters. A graph theoretical analysis of technology flows between industrial sectors, using technology indicator (R&D, patents and technical staff is used as technology indicators) weighted input-output relations in the identification of flows, is supplemented by a survey based analysis of innovation flows. The definition of a cluster in this study rests on the assumption put forward in DeBresson (1996;1996): innovative sectors cannot innovate alone, they need supplier industries for new components and user industries for new applications and requirements. The innovative clusters are identified from "innovative activity matrices", which are matrices inspired by input-output tables, but in stead of measuring flows of goods and services, the cells in the matrix expresses a flow of product innovations at the industry level. An analysis of this sort rests on the availability of extensive survey data on innovative interdependencies. In the Danish case, data from the European Community Innovation Survey (C.I.S.), carried out in 1993 and covering innovative activity during the period 1990-1992, are used. The Danish C.I.S. questionnaire included supplementary questions on the supply of product innovations in the form of means of production, raw materials or intermediary goods to main user industries, as well as on the participation of firms in other industries in the development process. On the basis of this information a matrix of innovation flows can be constructed.[11]

The diagonal of figure 3 shows that intra-industrial innovation flows, measured as percentage of firms supplying innovations, are predominant. *Manufacturing of electrical machinery and apparatus* is a general supplier of innovations, supplying close to all other sectors in the system. *Machinery, iron- and metal industry, rubber and plastic* as well as *chemical industry* (excl. pharmaceuticals) are also general suppliers of innovations. The main characteristic of these industries is that the percentage of firms supplying innovation to a single industry is relatively low, which could indicate a high degree of specialisation between the firms, regarding the industries, that are main receivers of product innovations.

As a contrast to these general supplier industries we find a number of industries with a high intensity of innovation flows to few other industries. All firms in the *mineral oil industry* have supplied product innovations to firms in the *food and beverages industry, public utilities, construction* as well as *transportation*. All firms in *manufacturing of office machinery and computers* have supplied product innovations to firms in the *graphical industry*, while 40-60% of the firms have supplied innovations to *textiles and clothing, electronics, manufacturing of electrical machinery and apparatus, public utilities, transportation* as well as intra-sectoral to other firms in manufacturing of office machinery and computers. More than 80% of the firms in *paper and pulp* have supplied innovations to *food and beverages*, while the *graphical industry* is a medium size receiver and *pharmaceuticals, chemical industry, iron and metal industry, machinery* and *transportation* are minor receivers. All firms in *textiles and clothing* are intra-sectoral suppliers of innovations. *Manufacturing of telecommunication equipment* has the *electronic industry* as a main receiver of product innovations.

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[11] The Danish C.I.S. survey includes only manufacturing, implying that it is only manufacturing that appears as a supplier of innovations in the matrix.

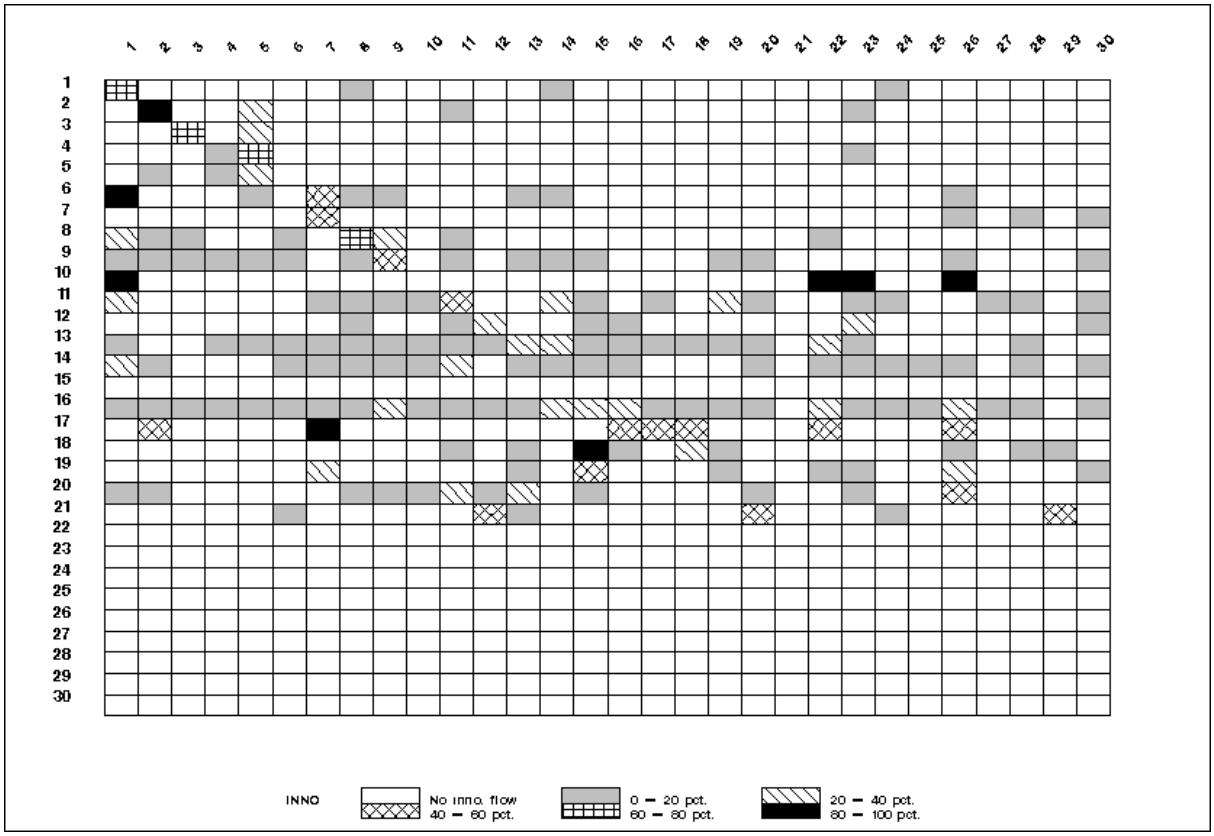

Figure 3: Innovation flows in Denmark, 1990-1992.

List of sectors:

1. Food and beverages	11. Rubber and plastic	21. Raw materials/other manufacturing
2. Textile and clothing	12. Stone, clay- and glass industry	22. Public utilities (electricity, gas, heating, water)
3. Leather	13. Iron and metal industry	23. Construction
4. Wood	14. Machines	24. Trade and repair
5. Furniture	15. Electronics	25. Hotels and restaurants
6. Paper	16. Electrical machinery and apparatus	26. Transport services etc.
7. Graphical industry	17. Office machinery and computers	27. Finance and insurance
8. Pharmaceuticals	18. Manufacturing of telecommunication equipment	28. Public administration, defence and social insurance
9. Chemicals	19. Instruments	29. Teaching
10. Mineral oil	20. Transport (manufacturing)	30. Health and welfare institutions

Sectors no. 15 and 22-30 are included as users only, sector no. 21 is only included as supplier.

The two main types of supplier industries can be used for identifying two types innovative clusters:

- clusters consisting of a single industry which is a general supplier of product innovation to a broad range of receiving industries. This type of industry-cluster is important for the diffusion of technology in the economic system;

- clusters consisting of industries which are intensive suppliers to a single or few receiver(s) *as well as* the main receivers. In this second type of cluster, a close relation between the supplier and receiver industries is assumed in the innovative process.

Figure 4 shows the information links, measured as active participation in the development process, between industries. The "dimensions" of figure 3 are maintained, thus breaking some of the logic of a traditional input-output table: As the rows contains innovation suppliers in both figures, the flows have opposite directions. This can be illustrated by the relations between paper and food & beverages. Food & beverages is an important receiver industry of product innovations from the paper industry, and between 40 and 60 percent of the firms in the paper industry indicate, that firms from the food & beverages industry have participated actively in the development process. This finding of close relations between paper and food & beverages is supported by the findings of Christensen et al.(1996) of developments of packaging playing an important role for the food and beverages industry.

The relation between paper and food & beverages is one example of the assumed relations between innovation suppliers and their most important user. The relation between manufacturing of telecommunications equipment and electronics is another example.

Identification of innovative industry clusters of the above kinds can be important supplements to the production cluster studies presented in section 2 and 3, since they can contribute with a dynamic angle which is largely missing in the production-defined clusters. In relation to the agro-industrial complex and the food and beverages resource area, figure 3 shows that it might well be that biotechnology is crucial for the development of this area, but food and beverages have a wide range of innovative sources and the industry plays a particularly important role as a user of innovations from the paper and mineral oil industries.

The identification of an innovative cluster around electronics is another important finding in relation to understanding the forces driving technology development and diffusion in the economic system.

Since the findings presented here are part of an ongoing research project, we have only scratched the surface in relations to the analytical possibilities of this kind of analysis. Thus the need for a development and improvement of both the methodology and data collection is obvious.

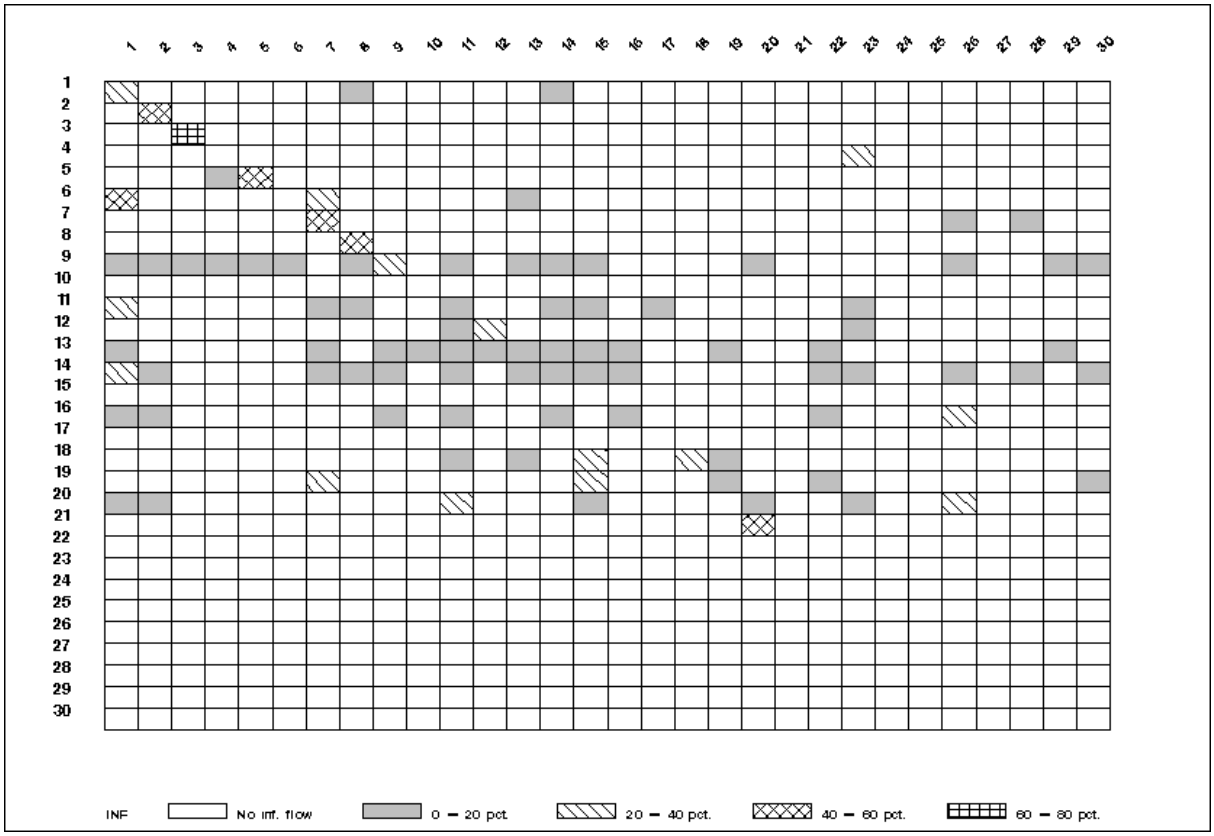

Figure 4: Information flows (active participation in the innovative development process) in Denmark, 1990-1992.

List of sectors:

1. Food and beverages	11. Rubber and plastic	21. Raw materials/other manufacturing
2. Textile and clothing	12. Stone, clay- and glass industry	22. Public utilities (electricity, gas, heating, water)
3. Leather	13. Iron and metal industry	23. Construction
4. Wood	14. Machines	24. Trade and repair
5. Furniture	15. Electronics	25. Hotels and restaurants
6. Paper	16. Electrical machinery and apparatus	26. Transport services etc.
7. Graphical industry	17. Office machinery and computers	27. Finance and insurance
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9. Chemicals	19. Instruments	29. Teaching
10. Mineral oil	20. Transport (manufacturing)	30. Health and welfare institutions

Sectors no. 15 and 22-30 are included as users only, sector no. 21 is only included as supplier.

5. Some conclusions

This paper has described how a framework (resource areas) for making technology and industrial policy, based on theoretically based cluster studies, has been implemented and modified in Denmark in the 1990s.

Furthermore, the paper has shown that the concept of clusters has been, and still is, related to very different types of studies and properties of the observed objects. If one factor linking all studies and types of clusters together is to be extracted, it must be the knowledge base, which explicitly or implicitly is present in all the above mentioned clusters. If a definition of a cluster is to be proposed in this concluding section, it has to relate to this common knowledge base: *a cluster is a group of firms, an industry, or a group of industries, which exists in relation to a strong knowledge base*. The knowledge base does not necessarily imply high technology, as with the case of agro/food and beverages, but a distinct knowledge base is still present. In the agro/food case the knowledge base is developed through the existence of a home market with close linkages between users of equipment and manufacturers of machinery for the use in this cluster. An important part of the knowledge base is created in the interaction between the users and suppliers, thereby resulting in a co-evolution between their respective industries, which tends to produce international competitiveness in both their fields. In the resource areas the knowledge bases are expressed as strength positions, and because of the generally very broad definitions, some resource areas have more than one strength position. This is e.g. the case in the consumer goods and leisure area, which includes both production of electrical equipment and traditional, more design based industries such as furniture, as well as some services.

Also ways of identifying clusters have been discussed in this paper. One way is to apply measures of trade specialisation, by identifying areas of comparative advantage in international trade. Such a procedure was e.g. followed in the Porter related studies. Other variables, such as value added, production and R&D, have been used as well. Another approach has been to identify vertical relations in the economy. Such relations can be identified at the micro level, mainly through case studies, while input-output analysis is a widely used methodology at the level of the industry. In this regard graph theoretical techniques for identifying important linkages, appear to be a promising method for further analyses. In terms of methods for application in future research the use of patent statistics as a means of identifying clusters, based on technological proximity, has been little used in the Danish context.

Policy has played an important role in this paper, since the major part of the cluster studies has been carried out with specific policy aims as a major driving force. It is obvious though, that theoretically based studies and practical policy actions do not always combine easily. While theoretically based studies aim at providing clarity and coherence in the analysis, policy making is concerned with 'muddling through' the complex reality. An example of this trade-off can be found in the history of the Danish resource areas, discussed in this paper. On the one hand, it can be said that the areas are to some extent based on theoretically based cluster studies. On the other hand each resource areas also have the function of acting as a framework for dialogues between firms and public authorities. Hence, it would not be wise in a policy context to exclude some firms in certain sectors, because such sectors were not identified as a cluster or as a part of a cluster. Thus, this trade-off should be acknowledged, so that a balance between allowing for pragmatic policy making (with more than a single aim) on the one side, while not losing the

theoretical foundation on the other, can be maintained.

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