Building Regional Competencies

The Industrial Enzymes Industry

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- The Industrial Enzymes Industry

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Building Regional Competencies

- The Industrial Enzymes Industry

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Abstract

This paper analyzes the foundations of regional knowledge and its long-term impact on the region's companies' and how a particular knowledge has developed an ability to stay competitive within a specific technological field. The case illustrates how the Copenhagen region has been able to develop a dominating position in the global market for industrial enzymes from 1870-2004. The case of industrial enzymes shows how a region has been able to build sustainable competitive advantages from its distinctive competencies. This is done through a mixture of outsourcing and in sourcing of competencies, knowledge and technologies from other regions in a ramified set of interacting networks. The key personnel within the regions firms are deliberately allowed to engage in the formations of these non-disclosure network activities so that professional knowledge communities has been established across regional boundaries and thereby formed the basis for globalization of the knowledge and the markets for industrial enzymes. Last but not least the paper demonstrates how the region's major firm, Novozymes, the world-leading manufacturer of industrial enzymes, even before the term virtual organization came into fashion, positioned itself as an interactive partner in the center of a globalized system of academic institutions, customers and clients.

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Introduction

The industrial enzymes business has emerged from a research idea back in the 1870'ies that developed into a single technological path before it eventually became a globalized industrial segment. Along with the formation of the industrial enzyme business the industrial pioneers simultaneously created what became the industrial skill and competence base that 100 years later became the political rationale for modern Denmark's move into the world of biotechnology (Nelund & Norus, 2003).

In the late 1980'ies a national technological program in support of the new biotechnologies was launched. From the program it is clear that the tradition within enzymology is one of the major arguments for the development of a national biotechnology strategy (Knudsen & Norus, 1989). This was not a great surprise since firms centered around the Copenhagen area like, Novo Nordisk (now. Novozymes[*]), Chr. Hansens Labs, the Carlsberg Brewery in terms of their markets shares, their percentage of the available patents in the area and their impact on the overall Danish economy are powerful actors in this new field of Biotechnology.
The major firm Novozymes is specialized in the development of customized enzymes for industrial purposes such as detergents, washing powders and starter cultures for industrial processes. Chr. Hansens, the first private company to market an industrial enzyme backs in the 1870'ies. An enzyme they produce today throughout the world along with more modern product lines in the areas of food ingredients and pharmaceutical development. Compared to these firms Novozymes is a late-comer since Novozymes started their enzymes business in 1941. Ever since Novozymes has introduced almost every new industrial enzyme on the global market, which make the firms the world's largest manufacturer of enzymes today with a market share of about 45% (Novozymes.com, 2003 Annual Report). Based on an advanced biotechnological platform Novozymes today produce and sell more than 500 enzyme products in 130 countries. However their patents portfolio consist of over 4000 single enzymes to be utilized in the future, most probably in the pharmaceutical area. In periods where other firms,

[*] Novozymes was established in the year 2000 after a de-merger from their original owner the Pharmaceutical company Novo Nordisk. Before that the Novo Nordisk Enzymes Division was one of two divisions within Novo Nordisk.

like Belgian Solvay and German BASF have focused on special areas in the industrial enzymes markets Novozymes has insisted on being present in almost all major areas of the business. Yet other European firms like the Dutch Gist Brocade sold their enzymes division to Novozymes biggest competitor in the market, Genencor back in the 1990'ies. The strong presence of a critical mass within industrial enzymes in the Copenhagen Region has allowed knowledge and ideas to flow within the particular organizations and their global partners and competitors. Especially Novozymes and Chr. Hansens Lab have taken the risk that knowledge would leak from the organizations in other directions in order to get access to important knowledge from their same partners.

Therefore the paper unfolds from a theoretical discussion on the concepts of sticky versus leaky knowledge. This section also introduces the articles distinction between networks of practice and communities of practice. The section flesh out the idea that in order for the region to maintain and develop its knowledge base it has to balance sticky and leaky knowledge. This will be followed by an outline of the methodological framework which is based on a combination of: 1) an in-depth case-study of Novozymes; 2) a historic study of the development and foundation of the industrial enzymes in the Copenhagen Region from 1870-2004; 3) a database research in the US patent statistics on the world-wide patenting behavior in a smaller segment in the area of industrial enzymes from 1982-2004.

The empirical analysis falls in three parts. Part I is a historical analysis of the foundation of the knowledge in the region explains how enzymology in the first place came on the agenda and how different actors in the field both firms, universities, engineering schools at a very early stage created a viable platform for the development of industrial enzymes. Part II is an in depth case study of how Novozymes and their particular organization of its development activities based on global network activities. Part III is a data base analysis of the patenting behavior in a single area of industrial enzymes from the US patent statistics. On a global scale this analysis reveals three interesting points. First, only a handful of nations are specialized in the area such as USA, Japan and Denmark. Second, Novozymes is the single most dominating private company in the area. Third, the study reveals that only two groups of researchers within Novozymes are responsible for all the firm's patents in the area from 1982-2004. Only few overlaps can be identified between these two "communities of practice" over the years.

Research Methodology

The data material consists of three different data sets. A historic study on the evolution of the industrial enzymes industry where data mainly consist of documentary texts and historic analysis's about how the main actors, individual researchers, research institutions and business firms with vested interests in the industrial enzymes business have developed the specific field of knowledge and maintained this interests over the years. The main source of data material stems from scientific dictionaries (e.g. The Kirk-Othmer Encyclopedia of Chemical Technology, (John Wiley 1992)), firm chronicles (Holter & Møller, 1976; Richter-Friis, 1991) as well as historic information that can be found on the companies and specific institutions official web-sites.

The second part of the study is a case-study on the organization and development of the Industrial enzymes within Novozymes (Fingeret, 1996). The purpose of the this qualitative study is to explain how the largest single manufacturer within the development of industrial enzymes have been able to develop its internal skill base through a combination of its internal organization. (both the headquarter in Copenhagen Denmark and in their subsidiary in Davis, California). The firm creates a very active dialogue with their main customers in a variety of market segments. The nature of the collaboration between the R&D takes place in the Danish headquarter and the research unit within Novo Nordisk's subsidiaries. This proves how the local knowledge, the knowledge within the region, continuously are been challenged by the integration of networks of practice and interaction within existing communities of practice throughout the globe. This part of the study has been done through intensive interview studies both in Novozymes headquarter in Copenhagen and in their R&D center in Davis, California (Fingeret, 1996)[1].

[1] Fingeret, a former graduate student of mine, spend a year on doing interview studies and participative observation research in Novo Nordisk Enzymes Division for her master thesis.

Last but not least data has been generated from a data base study on the patenting behavior within the industrial enzymes business. These data is generated from the United States Patent and Trademark Office. This public database consists of all granted patents in the area of industrial enzymes from 1982-2004 (www.uspto.gov). The purpose of the database analysis is to qualify that the region and its main knowledge producers (researchers, companies and institutions) over the years have been able to develop new innovations and combinations of new innovative production processes that have commercial value within the world market in industrial enzymes. An interesting aspect concerning patent data is that it besides what company/institution who has the patent also reveals the group behind the patent meaning that it is possible to see the group dynamics within a specific group of patents taken by a group/company/institutions. This type of data shows important dynamics within a community of practice and their possible connection to networks of practice both within a corporation and its subsidiaries and between a specific research group and its network partners.

Knowledge communities as carriers of industrial competencies in the region

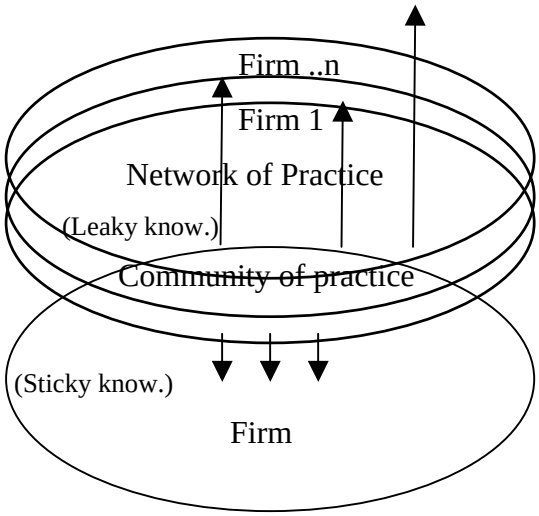
Well established research contributions to economic geography and regional competence building have traditionally focused attention on the changing organization of production in advanced industrial economies (Piore & Sabel, 1984; Lazonick, 1990; Kenney & Florida, 1993 & 2004; Porter, 1985; 1986; 1990) and how this provoked a move towards having specialized industrial districts relying on traditional regional manufacturing/processing skills of advanced industrial countries. Yet, others argue that knowledge in the region rely on a platform where high tech regions such as Cambridge, UK, Boston, MASS and Silicon Valley are functioning as marketplaces of ideas that drives firm formations through network clustering (Hilpert 1992 & 2003; Casper & Murray, 2004, Nelund & Norus, 2003). This article will expand the discussion on how a single technological trajectory or skill base, industrial enzymes, that is fostered in a specific region, the Copenhagen Area, and how this particular knowledge have had long term impact on the development of industrial competencies within the region. The article will tap in to the discussion on globalization of business competences, essentially arguing that the region have benefited immensely from the globalization of different business activities that in turn explains how the region has been able to enhance its competitive strength in the technological area in question. I will argue that this

is the reason behind the regions ability to develop. I will argue that the success in the Copenhagen Region in the industrial enzymes is thanks to a unique combination of how to develop specific skills both in the area of production and in the development of the specific enzymes. Also the organizational design have had great impact on the success because the management within these firms have given priority to this particular knowledge could develop side by side with networks of practice both among the regions companies and research institutions and among customers, clients, research institutions and competitors at a global scale

Seely Brown and Paul Duguid explain from a corporate perspective how organizations in knowledge intensive industries have to deal with the problem of the sticky versus leaky knowledge. Sticky knowledge being that the region has to give infrastructure and opportunities for knowledge creators (firms, research institutions and researchers) to stay in the region to develop research ideas and foster new companies in the technological area in question. Leaky knowledge being the argument that a region at the same time has to disseminate and display its knowledge in forms of research papers, its ability to sign patents and the presence of competitive companies that explore alternative and complementary technologies. As opposed to other researchers (Constant; 1984; 1987, Wenger & Snyder, 2002; Garud & Kanøe, 2002; Norus, 2002) in the field of communities of practice Duguid & Brown (2001) distinguish between communities of practices and networks of practice. By making this distinction Duguid & Brown helps us to understand why certain firms are unable to capitalize on their patents and research and development activities, and often see them being development outside the domain of the firm.
As illustrated in figure 1 Duguid and Brown argue that communities of practice exist within a specific a firm/organization with the distinct aim to develop a specific task. These communities are often cross-functional units and exist or are created to take care of specific development projects or developmental tasks. In addition networks of practice can be seen as relations that are looser because they exist across the boundaries of the firms and are created in order to develop a certain work practice often through professional organizations.

Figure 1: Fluidity of practice knowledge

Region



Instead of discussing the two concepts them as opposites I will argue that seen from a 'knowledge in the region' perspective these concepts have to be balanced in order to create a vibrant knowledge base from which organizational development, technological renewal, and industrial competencies can blossom. As the analysis will point out the formation of the particular knowledge around enzymology in the Copenhagen region have been sticky in the sense that it has allowed a network of practice to be established around university departments, private companies and private research labs (Seeley Brown & Duguid, 2001). At the same time the region has been leaking and exporting its knowledge by corporate expansion, customer interaction and exchange of knowledge, allowing the firms, institutions and individuals to import new knowledge that could be used for improve processes and be utilized to import new technologies e.g. genetic engineering to advance and modernize the regions knowledge base. Theoretically I will argue that a region must balance between sticky versus leaky knowledge. Hence to ripe the fruits, the region must on the one hand be acknowledged as open-minded and willing to share its knowledge with its potential partners expanding in to the field and region. On the other hand the region must not reveal or loose momentum so that its skill base is attracted elsewhere.

The concepts of networks of practice and communities of practices imply that networks are seen as bounded to the development of professional identities both within an organization and between organizations. Hence networks have three faces with important implications for knowledge in the region perspective. First, these networks is a functional means of knowledge

development that can be traded and designed between organizations and 2) Secondly networks are fluid in the sense that knowledge flow between people and therefore are personal assets that can be used as basis of entrepreneurship elsewhere (within the region and outside the region). 3) Third, networks are carriers of technological trajectories or technological paths and therefore also a necessary component in the formation of an industrial tradition.

Figure 2: The geography of communities/firms and region

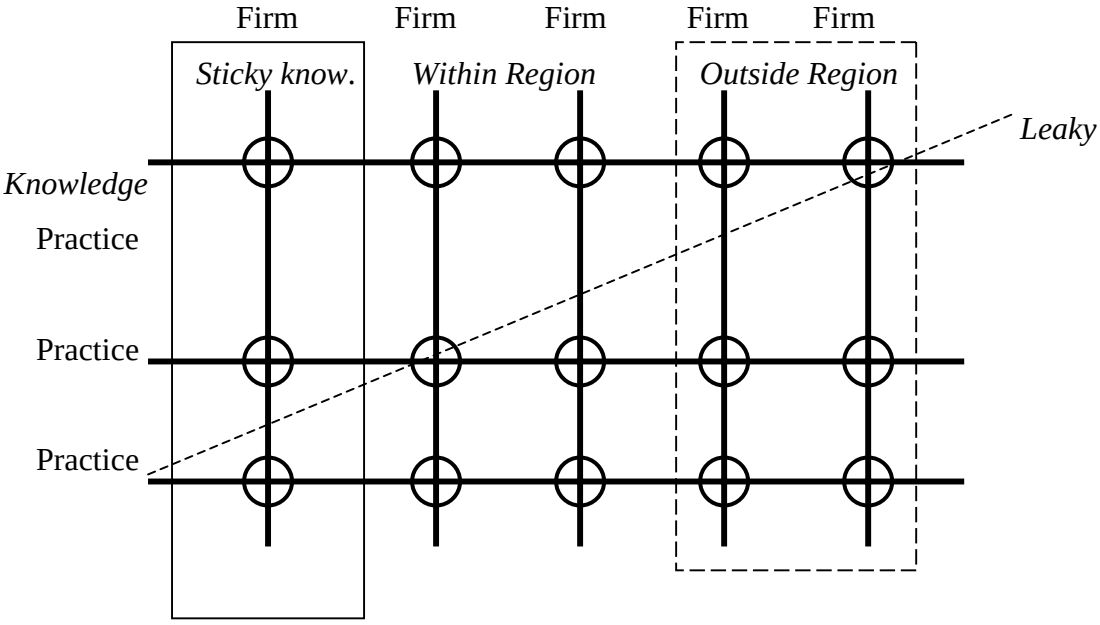


Figure 2 seek to illustrate that “Networks of practice” are regarded as the basic mechanism allowing knowledge to flow in and out of the region. These networks of practice are essentially the carriers of knowledge that foster collaborative arrangements and that allow a certain flow of knowledge between the region’s major companies and institutions and their global partners. Eventually these networks of practice have been able to reorganize and renew industrial competencies, to foster new businesses, but also to attract political attention throughout a period of 130 years. Whereas “communities of practice” are viewed as driving internal force within the major companies who are responsible for developing the internal skill base so that the firm stay competitive in the markets.

Methodologically this means that we must look for historical explanations of how clusters of networks have evolved. Also that we have to investigate the dominating organizations and institutions and research communities to find out how they have established and maintained these networks so they are able to build sustainable competitive advantages both in the economic sense and in the sense that the knowledge development within the technological paths and within the region so that the knowledge continuously are regarded as competitive in the professional societies. In this article this is handled by a combination of three types of studies, a historic study on the evolution of the industrial enzymes business, a case study of Novozymes and their ability to stay competitive within the technology and how they have globalized their activities as a world market leader and through a patent study on how the Copenhagen region compete in the area.

The Industrial Enzymes Business

According to Random House Unabridged Dictionary (2´nd ed.) enzymes are: “any of various proteins, as pepsin, originating from living cells and capable of producing certain chemical changes in organic substances by catalytic action, as in digestion”.

In other words enzymes function as catalyst in chemical and biological processes without being destroyed during these processes. These processes would either be very slow or would not take place at all without adding the enzymes. Another advantage is that enzymes liberate and can be used in new processes when the chemical reactions have taken place. In industrial processes specialized enzymes are therefore used in order to get a large amount of the wished products with a minimum of unwanted byproducts.

The industry for washing detergents (washing powders) is one of the major users of industrial enzymes. The enzymes make it possible for the producers of washing detergents to make a product that allow the consumers to wash their clothes at very low temperatures. At the same time other enzymes preserve the colors of the fabric. The textile industry is another major user of enzymes. Highly specialized enzymes allow e.g. Levi Strauss to manufacture jeans with fashionable looks. Yet other enzymes are used to give the textiles their softness without changing the durability of the material.

The above examples just serves as an illustration of how specific enzymes can be used to make product innovations that satisfies both manufacturing and consumer preferences. The industrial use of enzymes can moreover be seen as an improvement of the environment because washing in low temperatures contributes to bring down the use of energy. Add to this that enzymes are liberated after the process and the waste can be used instead of fertilizers in the agricultural sector. Therefore consumer preferences, industry use and political priorities in terms of environmental protection can be unified through the use of industrial enzymes. For these reasons the commercial interests from a whole variety of industries has increased as a response to the public regulation in environmental protection. However as indicated in the following section, the prizes in the enzyme market has generally fallen over the last year, and two of the major players, the Dutch company Gist Brocade have withdrawn from the market in the late 1990'ies leaving business in the first place to Novozymes, German BASF, Belgian Solvay and the major American companies, Genencor and Maxygen,

Building regional knowledge

From a Danish perspective there were three primary actors involved in the initial phase of the evolution of the enzyme technology: Christian Hansen, the founder of Chr. Hansens Labs in 1874 and the first company in the world to market an industrial enzyme; the privately funded R&D department, Carlsberg Laboratory and; Chemical Laboratory at the University of Copenhagen. However the inspiration to start a research project on industrial enzymes came from a Swiss, Dr. Rudolph Schatzmann who published a paper in 1871 that was concerned about the lack of reliable methods, process technologies, in the production of rennet. Rennet is an enzyme, which is extracted from calf stomachs and makes milk to coagulate when making cheese. Dr. Schatzmanns paper is finished with a request for the development of a process that makes it possible to produce a rennet that were pure, non perishable and homogenous (John Wiley, 1991). Observe that it is the discoveries in process innovations that Dr. Schatzmann was interested in having developed. It was neither a new enzyme that was looked for nor was it a new source from where a better rennet could be extracted. This is of great interest because we would argue that this fundamental insight in processing (methods of production) that Christian Hansen later on developed as a research assistant at the Chemical Laboratory at the

Copenhagen University is one of our main arguments for the status of Novo Nordisk as the leading manufacturer in the market for industrial enzymes. There is clear evidence from out data that this fundamental interest in the development of process technologies that dates back to Christian Hansen's ideas, and thereafter handed from generation to generation of engineers, biochemists, and pharmacists. Also in the history this fundamental interest in process technologies can be found and must be the main reasons that Novo Nordisk kept their enzymes division in the 1990'ies when other leaders e.g. Dutch GIST Brocade sold their enzymes business to American Genencor..

From the development of a new process technology in the production of rennet Christian Hansen started his firm, Chr. Hansens Labs. in 1874. Today Chr. Hansens Labs. is a world wide company with production subsidiary in Ireland and production plants located outside Copenhagen, in Milwaukee, in the Toronto area, in Adelaide, and in Milan. Moreover the firm has established sales companies worldwide. Chr. Hansens Labs. is still producing rennet, but has expanded have become a diversified business with roots in the pharmaceutical business and food ingredients business.

At almost the same time as Christian Hansen developed a new process to produce rennet another major research institution, Carlsberg's Laboratory was founded. In 1876 the brewer Carl Jacobsen build up his own research institute. Carlsberg's Laboratory has played a major role in the research in enzymatic processes in barley and yeast. In the chronicle edited by two Danish historians (Holter & Max Møller, 1976) it is interesting to see how much interaction and collaboration there has been across institutional boundaries between University of Copenhagen, Novo Nordisk and Carlsberg Labs. Since the chronicle is focused around individual personalities it gives a very good insight in how networks are created and maintained between actors. Another very interesting aspect of the Chronicle is that it seems like there has been no or at least very little interest to share between Chr. Hansens Labs. and Carlsberg Laboratory since no direct references to Chr. Hansens Labs are made. However it seems like in the moderns time there has been quite many contacts between Novo Nordisk and Chr. Hansen (Richter-Friis, 1991). This indicates that Novo has been able to position themselves in the center of the Danish Activities.

Also Danisco, the main distiller and sugar producer in Denmark, can be acknowledged as one of the main reasons behind the development of industrial enzymes. The insight especially in the process technologies has been reached thanks to their pioneering research in fermentation technologies. Still there are some informal relationships between Novo Nordisk and Danisco in process development. But again here there is also competition and controversies alongside the network interaction between the regions firms. In Novozymes 2003 Annual report it is noticed that the firm have an undecided lawsuit where Danisco claims that Novozymes have violated one of Danisco's patents (Novozymes.com).

Strong relationship between pioneering researchers with different institutional background and the establishment of firms at an early stage gave Denmark a unique opportunity to develop a national competence in the production and development of industrial enzymes. The ability of the firms to make use of the theoretical knowledge that came out of the universities lead to a demand for candidates with specific knowledge in enzymology that forced the universities, University of Copenhagen and the Technical University (The School of Engineering) to give enzymology high priority when their curricula. Thereby the collaboration between pioneering researchers, industry and universities reinforced the development and creation of the technological path that gave the region an infrastructure from which its firms and institutions could further expand its activities into a globalized market.

Seen from an evolution of technology perspective, the case of industrial enzymes shows that a trinity of actors with different institutional and organizational background has been actively involved in promoting the industrial competence building within the region. The case shows that a new technology is institutionalized through a variety of fora. We find it fruitful to think of the involved actors as belonging to different organizational contexts that through interaction, construct a shared set of values and norms that has the form of a community. The outcome the interaction is the creation of network relations where the actors fill out the structural holes in the community (Burt, 1992). Therefore, the interaction can be seen both as a competition for social space, being accepted or acknowledged as a legitimate actor by the members of the community, and as strategic fit and learning processes. Social fora, or networks, can therefore be seen as informal meeting places where the involved actors shape or define each other's strategies. However, the involved actors do not have identical interests.

Instead they have a common interest in promoting the technology and through interaction and information sharing they acquire the roles to play. In other words, the technological development goes hand in hand with some institutional processes, taking place within a variety of networks. These networks function as mediators of strategy creation for the involved organizations, institutions, and individual actors. Thus, the concept of strategy and strategic thinking is not confined solely to the individual firm, but has to be understood in a larger social context. This transforms the concept of strategy into a question of how the firms are able maneuver and utilize the national/regional institutional context as a platform for their existence. In this strategic game has Novozymes been the most successful explorer and exploiter of the enzymes technologies.

The outcome of the historic study is that the development of industrial knowledge are to be understood as a dynamic process and an asset that are developed through interaction among the region's organization; customers, consumers, R&D institutions, competitors and suppliers. The question is therefore how these different groups have been able to sustain their interest and keep the competitive advantage that the region in general and Novozymes more specifically enjoy. How has Novozymes reached that status without being first mover? How have Novozymes been able to build up its competencies through interaction and network formation?

The domination of Novozymes in the industrial enzymes market

Two brothers founded Novo Nordisk in 1925, Thorvald & Harald Pedersen under its initial name Novo Industri. The one brother was a trained pharmacist and the other held an education as a mechanical engineer that gave Novo Industri advancement for success in the fermentation of insulin and penicillin. Again observe the combination of the skills and interest of the two brothers; one with an interest in the product development and the other with and interest in the development of process competencies.

Another major reason for their advancement was the fact that they both had been employed at different public research institutions e.g. Laboratory for Animal Physiology at the University of Copenhagen which was headed by the Nobel Prize winner Prof. August Krogh and in a

company called Nordisk Insulinlaboratorium. This company had specialized in the production and development of insulin, and in this firm professor August Krogh also was the leading figure, since he was the first to isolate insulin from pig pancreases[2]. The reason for the establishment of Novo shall be found in some internal problems at Nordisk Insulin Laboratorium about the rate and direction of the company.

Especially in the beginning it was thanks to their skills in scaling up production processes that gave Novo Nordisk advantages in the insulin market. These skills in the process technology can also be seen as one the factors in the decision in the involvement in the enzyme production. However it was not until 1941, during the 2´nd World War Novo Industri started to build up competencies in enzymology. This change of focus was caused due to the shortage of the supply of pig pancreas and that prizes were substantially higher in the war period. Therefore Novo Industri started a R&D project with the aim of finding new substances which could be used in other industries in order to produce more products from the same raw material. During the research the R&D team discovered that the enzyme, trypsin, in pancreas was not destroyed during the extraction of insulin, but instead precipitates[3]. Trypsin is used in tanneries to soften the leather and make the skins more flexible. Today Novo Nordisk has engaged in the development of enzymes to different industries such as: different kinds of detergents[4], tanneries, textile industries, dairies, breweries, starch production etc.

Since the 1940'ies, when the development of trypsin began, the strategic focus of Novo Nordisk has been concentrated in two major business divisions, the Health Care Business and the Enzyme Business. The aim of the Enzyme Business Division (now a separate company Novozymes) is to deliver, develop and produce biological solutions to industrial problems in close collaboration with their customers. Today the Novozymes have offices and production units in 23 countries throughout the world.

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[2] Later on Nordisk Insulinlaboratorium changed its name into Nordisk Gentofte. In 1989 Novo Industri merged with Nordisk Gentofte and turned their name into Novo Nordisk, but at that time the two founders and Prof. Krogh were all past away.
[3] Trypsin is a proteolytic enzyme of the pancreatic juice, capable of converting proteins into peptone.
[4] The detergents varies greatly in between nations and therefore the enzymes have to designed differently if it is a compact powder or a fluid detergent (John Wiley, 1991).

Organizational design – Balancing leaky and sticky knowledge

In explaining the strengths of Novozymes in the enzyme business two factors are important:
1) The project organization through which Novo Nordisk through network formation adapt to customer preferences and user needs as a basis for product development.
2) Globalized knowledge building through network processes of search and technological learning

Project organization
The enzyme Division is organized in projects where each unit seek to optimize the use of industrial enzymes in as many industries as possible. Ideas to new products appear normally through information from users/customers and the customers of the users (Lundvall, 1985; von Hippel, 1988; 1990)

The project groups vary in size, but they are very seldom more 10 persons round each project. The groups are always composed of different educational background; engineers, microbiologist etc. Each member will not be connected full time in one project. Instead the project members join the group whenever it is necessary throughout the project. This allows each employee to be members of more than one group at a time. This gives a flexibility in the in the enzyme division. Moreover it makes it possible to share information across the different projects thus the internal communication secure a maximum of spin off between the ongoing projects. The project organization furthermore function from a principle of "integrated product development" which means that the development and production are integrated parts. By this Novo Nordisk avoids that two units or departments have to compete for resources and that modification of products can be done very rapid and more flexible that if two different group were to take care of the functions. The concept of integrated product development groups seems to stem from the antecedents of the founders.

The project organization seeks to give autonomy to each project in order to establish a platform for external contacts and the active participation and creation of networks of practice in order to fulfill the goal project. Therefore the project organization allows the formation of a

whole variety of different networks to customers, R&D institutions on a person-to-person basis (Kreiner & Schultz, 1993). The close contacts to the users means that Novozymes rapidly adapt to customer preferences and changes in consumer habits. The day to day basis of the information sharing with their customers stems also from the technical service that Novo Nordisk make available to their users. The technical service includes that a member og project helps the customer to optimize their processes. In this initial phase scale up and adjusting the processes it is sometimes necessary that the developed enzyme have to be modified in order to comply with the demands of the customers. Despite all the best intentions and designed routinized procedures for customer service and technical assistance, Norus article on the Danish juice company, Rynkeby, shows that these relations not always ends up with a successful development of new products seen from the perspective the customers (Norus, 1997).

Nevertheless, these relationships give an incomparable insight in the production plants and therefore an insight in how the enzymes are functioning in large scale. Moreover it gives Novozymes ideas of how to make new variants of the same product in order to sell it to other companies in the same business. This can be seen as opportunistic behavior, but it is not. For example in the detergent industry, where the enzymes gives the products the specific characteristics that the large producers, like Proctor & Gamble, Unilever etc. are competing about, the agreement is that Novo Nordisk can sell an almost similar product with almost identical characteristics to the competitors. This means that some of the discounted products actually are as good as the brand names[5].

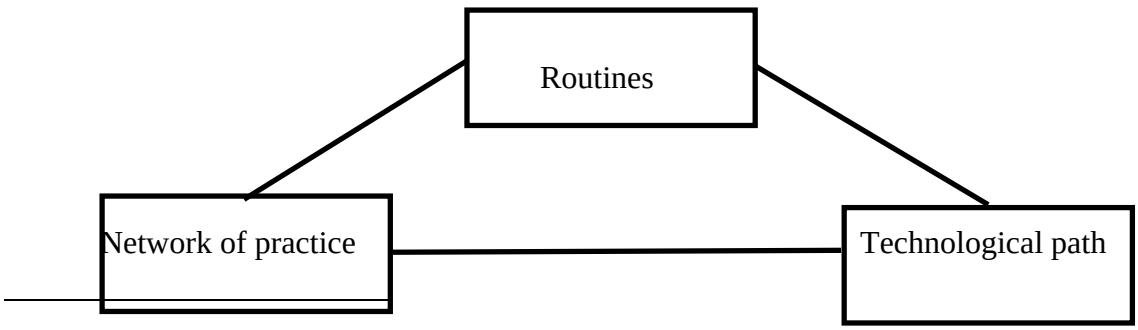
Globalized knowledge building

In the former section, the establishment of networks was regarded as some almost stabile and formalized communities of practices within the organization. Two factors are of great importance for the competence building that takes place in Novo Nordisk in terms of search and learning; the access to the employment of well-educated candidates and the access to theoretical knowledge and in the basic research that takes place at the University of

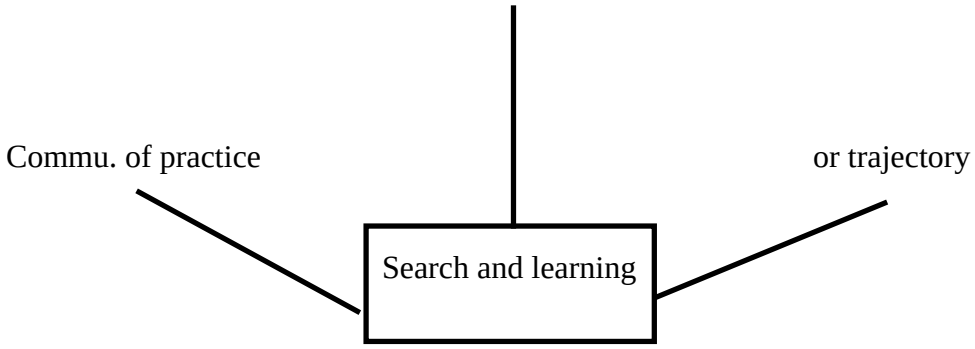
[5] This was a customer service announcement

Copenhagen and Denmark's Technical University. The relationships between these institutions and Novo Nordisk are on a person-to-person basis. These relationships involve also that some of the most talented students are invited to finish their studies and carry out their masters thesis's in labs of Novozymes. These types of network relationships also include the 23 countries where the Novozymes are represented throughout the world. In Davis, California the researchers are in close but still informal contacts to the key departments in enzymology at the nearby University of California, Davis (UC Davis)[6]. The ways of communicating and information sharing with both customers and research institutions do not vary from the description of the Danish context. Outside the public R&D system Novozymes, as previously indicated, have strong ties to the Carlsberg Labs. The collaborations are based on personal relationships due to common carriers in the Danish process industry or as former student fellows at the universities. These relationships are moreover reinforced by the fact that the employees are asked to participate actively in the research community by writing papers in research journals and presentations at academic conferences etc. Through this an almost invisible circle is established (see figure 3). that defines or institutionalizes a specific way to handle the development of knowledge and competencies in the firm. Hence the definition of the technological path, include a shared view of how organizational routines are embedded in the formations specific networks that in turn are seen as fora of learning. It is the interacting nature the organizational routines and the established network relations that through search and learning develop and keep up the technological path, and at the organizational level creates the industrial competence.

Figure 3: The principle of competence development



[6] UC Davis has a very strong competence in biology especially in agriculture

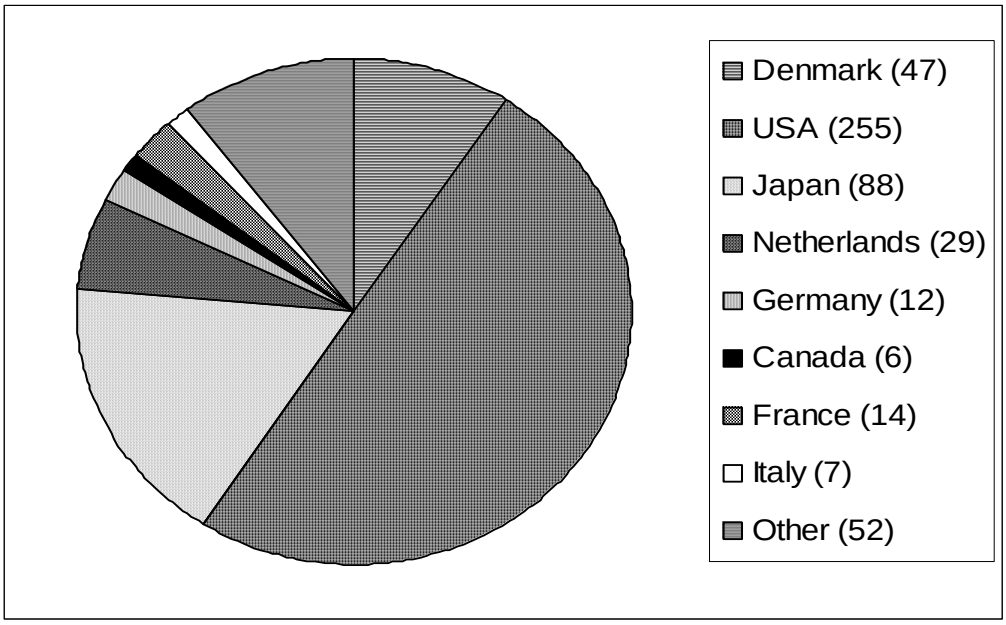


Seen from the perspective of the actors the circle are more or less invisible because they are all part of numerous network of practice and communities of networks where they at one and the same time are members of an organization, and members of a community of promoters of the technological path. Even that the interaction with customers and institutions are external to the organization that the individual is employed in. The aim of these technological communities or communities of practitioners (Constant, 1984) are that the members/actors share the same professional norms, identities and values in order to secure the life of the profession, and the members of the community. Therefore the successful development and an industrial competence, like Novo Nordisk development and utilization of the of industrial enzymes have to acknowledge how the actors have acquired and maintained their professional identities through network interaction and formation of overlapping "network of practice in the area of industrial enzymes.

Patenting Behavior in the Industrial Enzymes Business Industry (1982-2004)

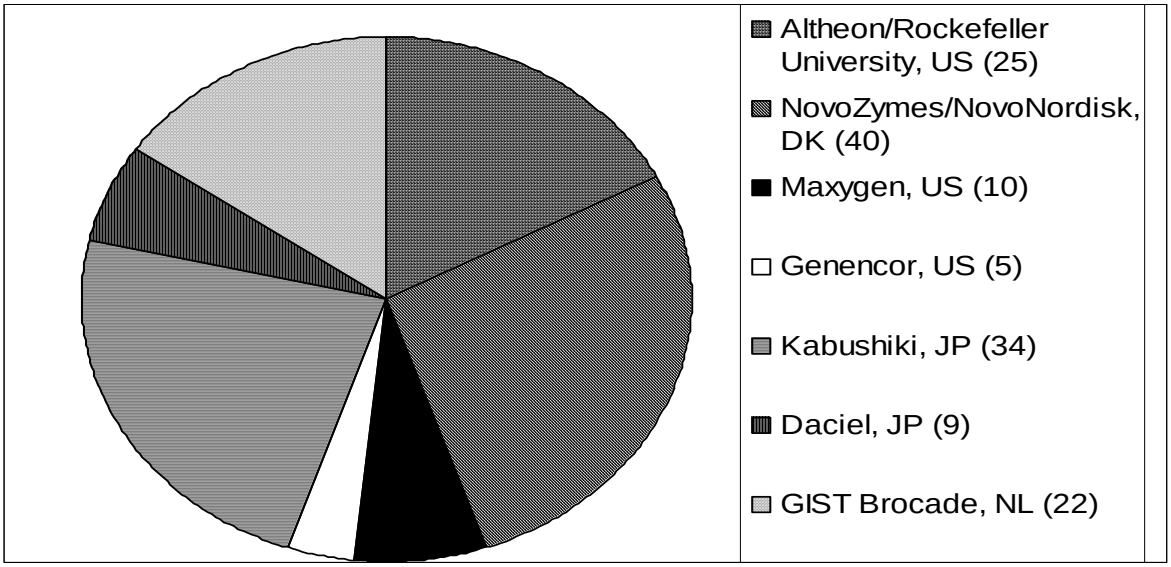
It would rather problematic to talk about sustainable competitive advantages stemming from interactive relationships in and out of the region relying on historic data and case studies without reflecting on how the region seem to compete within the state-of-the-art knowledge development. Ideally this could have facets such as knowledge production within the field of enzymology and other related areas. I have reduced the data collection to concentrate on the patenting behavior within the field of industrial enzymes. These data have been generated from the US patenting database (www.uspto.gov). Special emphasize have been on contribution of the individual countries in order qualify that industrial enzymes is an area of specializations in Denmark. Also whether the old competences are still in fashion when coming to the firms eager to patent their knowledge in competition and collaboration with regions.

Figure 5: Dominating countries in the area of industrial enzymes



From figure 5 it is clear that only a few nations have specialized in industrial enzymes with USA and Japan as the leading nations followed by Denmark. USA accounts from 255 of 510 patents granted in the area in the period 1982-2004. It is interesting that nations with very strong processing industries such as Germany and France is less important in this industrial area. Denmark's position as third after USA and Japan is quite surprising since only a few companies as mentioned are actively engaged in industrial enzymes development.

Figure 6: Patent domination within Industrial enzymes (1982-2004)



Source: (www.uspto.gov)

This is reflected if we focus on the companies that have been dominating in the period of observations, but here the picture change as can be seen from figure 6. The seven most dominating business firms account for only 155 of 510 patents in the area with Novo Nordisk as the single most dominating firm in the period. One must bear in mind that the Dutch Gist Brocade is no longer actively engaged in industrial enzymes.

A closer look at the data from the patenting analysis furthermore shows that two particular communities of practice, two groups of researchers within Novozymes/Novo Nordisk are responsible for all the firm's patents in the area of industrial enzymes from 1982-2004.

Only a few overlaps between these two "communities of practice" can be identified from the data set. This is a surprise because "the integrated project development" mode of developing within Novozymes should allow the people to engage in more than one group. However a closer look on these groups over the years have been more and more internationalized, especially with groups in Davis and North Carolina and Novozymes research groups in Japan. This observation supports my initial argument that in order to build sustainable knowledge within the region the must be able to balance leaky and sticky knowledge. The surprising stability within the research groups in Novo Novozymes when it come to patenting behaviors also demonstrates why Novozymes has been able to build a sustainable competitive advantage in the areas of industrial enzymes.

From a management point of view it is interesting that these two groups have not been involved in activities in the formations of any of the regions activities that seems to have been a lobbying job that has been handled by the formalized organization by research directors and other senior managers. The example shows two important aspects of knowledge communities with respect to regional development. First it show the stability and consistency of a community of practice necessary to build up long term competitive advantage within a certain firm. Also it shows how communities of practice have been decoupled from related networks of practice that seek to attract competencies, capital and political attention to the region, implying the existence of a division of labor between communities of practice and networks of practice that is left untouched by Seeley Brown and Duguid.

Conclusion

The paper shows how industrial enzymes development and production has become a Danish industrial specialty. The paper finds that the historic foundations for the country's specialization can be found in a unique combination of collaborations between academia and firms with special interests in the area.

Three important aspects of knowledge in the region can be learned from the case of industrial enzymes in the Copenhagen region. First, in order to build a sustainable competitive advantage the dominant player, Novozymes, allows key employees to foster and engage in knowledge communities risking that important knowledge leak from the organization to partner organizations and competitors both inside and outside the region. In a regional perspective the company develop competitive advantages by forming professional identities together with the regions major companies and research institutions such as Danisco, Chr. Hansen Labs, Carlsberg Breweries, University of Copenhagen and Denmark's Technical University. It is not hands on, but at an arms length support through mutual interaction at many levels at the organizations in question.

Novozymes organizational model is interesting since the established routines and the organizational behavior resemble what modern organization theory only recently has pointed

to when discussing the role of the virtual organization. Their virtual organizational model presented allows the company to attract new interesting knowledge from other region, to expand to other regions by close user-interaction with its global customers and by setting up research groups and production facilities through out the globe. An implicit implication for having this model to function is the existence of an invisible division of labor between communities of practice at the workplace and networks of practice of high positioned mangers in the regions major companies. Such an mediating "network of practicing managers" to have a regions knowledge to expand is left untouched by Seeley Brown and Duguid. Second, those communities with respect to regional development need stability and consistency so that a community of practice can emerge and from that start to develop long-term relationships that are needed to foster a network of practice. Third, since the two dominating research groups have not been involved in activities in the formations of any of the regions activities it seems that there are a separation between the formal R&D activities and the activities concerning regional formation. The first set of activities is left to R&D groups whereas the other set of activities is left to R&D directors and senior management. Hence communities of practice have been decoupled from related networks of practice that seek to attract competencies, capital and political attention to the region.

Last the paper demonstrates how the region has been able to not only stay competitive but expand its activities in the area by integrate knowledge from other regions. This has done by having a focus on developing this industrial segment through collaboration in networks. These network have had form both as internal networks within the business firm, communities of practice, especially Novozymes and Chr. Hansens Labs. Also more internationalized network collaboration has taken place within a variety of networks of practice that have allowed the firm to engage in interaction not only with their major customers with whom they design and almost tailor made these industrial enzymes, but also to international research communities and competitors.

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Web-pages:
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