

Technology Transfer as Driver for Innovation and Automation in SMEs

Experiences and results from different programs in Norway

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Abstract—Competence brokering for knowledge and technology transfer plays an important role in innovation and development within small and medium sized companies (SMEs). This type of activity focusing on cooperation between SME's and R&D environment has been implemented in various applications in Norway for many years. The transferred knowledge leads to company specific projects in innovation and development. In both national and international studies, it is documented that 60-70 % of the challenges and needs of SMEs in different countries are related to products, processes and international marketing. The basic idea of brokering is to improve collaboration between companies and R&D institutes in order to facilitate innovation, development and value creation. The major characteristic of the brokering is to visit companies, build trust, and systematically audit the challenges and needs, clarify and identify relevant projects, and assist companies to obtain and apply R&D knowledge. This can be done by individual cooperation between one company and one researcher, or within networks where more companies and researchers participate. The paper presents the Norwegian approach and experiences of competence brokering and technology transfer to SMEs in regional innovation and development. The work is based on action research, reflection, experiences from the brokers' point of view and literature studies, and focuses also on experiences from company specific projects which have resulted in significant improvements and better efficiency in production.

Keywords—*competence brokering; knowledge and technology transfer; product development; automation; collaboration*

I. COMPETENCE BROKERING AND TECHNOLOGY TRANSFER IN NORWAY

A. History of technology transfer programs

Various programs for knowledge and technology transfer from R&D institutes to small and medium sized companies (SMEs) started already in the early 80s in Norway, first as technology clusters for big companies. In 1982, a 3-year program was established aiming at collaboration between manufacturing companies in Jämtland, Sweden and SINTEF in Trondheim, Norway. SINTEF is the largest independent research organisation in Scandinavia. The evaluation created

positive attentions, and a similar 5-years pilot program was implemented in 1985 in one of 19 counties in Norway.

In 1989, District oriented Technology Diffusion (DTS) was started as a public 5-year program involving 9 counties, mainly peripheral ones, with one technology broker from SINTEF working full time in each participating county. During these years 2135 companies were visited, and 1011 companies managed to implement their technology related projects, where about 40 % were related to process development and automation. 334 different researchers were involved in the implementation. 24 % of the companies undertook repurchase of R&D within two years [1].

Technology Transfer from Technical R&D Institutes to SMEs (TEFT 1) started in 1994 as a nationwide 5-year program financed by the Research Council of Norway. There was one technology broker in each county working full time. The program was coordinated and managed by SINTEF with four venture partners. A total of 1840 SMEs were visited and 842 technology projects were carried out, nearly half within process/automation. The re-purchase of R&D services was now 34 %. Again the evaluation was positive and the program was recommended to be continued with some changes. TEFT 2 was along the same lines as TEFT 1 completed for another 5 years in 1989- 2003. During this period, 1872 SMEs were visited and 728 technology projects undertaken. Again the evaluation was positive and the program was recommended to be continued [1] [2].

In 2004, the Research Council of Norway took over the role as leader and responsible for this type of program for research dissemination. New programs were implemented, like Research-based Competence Brokering in 2004-2006, and the present VRI (Program for Regional R&D and Innovation) for 2007-2016. In the present VRI program there are 15 VRI-regions in the country. About 50 brokers are involved, and all work part-time. The program permits regional adaptations; among other things like choice of business sectors, type of industry, type of brokers, and so on [2].

B. Competence brokering/technology transfer

The competence brokering is about connecting companies (SMEs) to relevant research knowledge. This link does not occur by itself. There have been and are different barriers. Normally many companies do not come to the institutes, somebody has to visit them. It is necessary to consult SMEs on their home ground to encourage more companies to do research, use research and collaborate with research institutes and researchers. Therefore, it is necessary to have qualified persons who actively link companies and researchers. The main task of a competence broker is to identify issues the companies can benefit from by use of research, and connect them with relevant researchers. Public instruments and the companies themselves finance the cooperation projects.

The main tasks for the competence broker include:

- Visit companies and systematically audit their needs and opportunities
- Clarify and identify R&D challenges, and establish contact with relevant R&D institutes, or other parties that match the challenges, like suppliers of machines, tools, equipment and so on
- Develop, plan, initiate company specific projects, follow-up and conclude the projects
- Cooperate with regional parties for innovation projects, and also with the regional public support system for signposting and additional support, and provide contacts and competence through national and international networks

Most of the brokers in Norway are recruited from and work at R&D institutes. They are chosen due to their personal abilities, occupational background, relevant competence related to the target group/business sector they should work towards, wide network including the SMEs in the region, R&D expertise, and financial tools. They must be willing to travel and work independent. The brokers meet several times a year to share experience and increase their knowledge on business related matters.

To understand and be able to discuss with the management the broker should have an idea of what the main features in the companies are. Together they will identify challenges met by the company and evaluate how competence brokering may assist in meeting these challenges. Our experience is that the financing of projects is a necessary tool the broker must have access to. The motivation is built in this mechanism due the fact that the researcher is the receiver of the money from the program and from the company.

Good planning and preparation ahead of company visits are important for success to achieve a visit appointment with the company. The better planning and more research has been done in advance, the easier it is to find good companies and get into a dialogue with them. Before calling, it is wise to check out available data and facts to obtain good overview about the company.

C. Goals for competence brokering/technology transfer

There are two major perspectives that can be associated with the topic of competence brokering; the objective perspective and the practice-based perspective. Looking at the goals formulated for the mentioned programs the main goal is about the same. The overall goal has been to ensure value creation and competitive power in regional SMEs by enhancing innovation capability through systematic R&D activity. There are however two main goals or measures respectively related to the companies and the R&D institutes:

- Company goal: To promote greater focus on R&D activity in companies with little R&D experience in order to increase their internal innovative capacity, thereby enhancing value creation and competitiveness (stimulation of R&D demand)
- Institute goal: To strengthen the role of the research institutes as partners in collaboration with industry (stimulation of R&D supply)

Through the cooperation and the projects, the companies will increase their involvement in R&D efforts, innovation, product and process developments, and the R&D institutes will strengthen their role as valuable partner for the SMEs.



Fig. 1. Active participation and equal understanding between company management and researchers are important. A professor explains how to streamline a process with new tools while a student is watching [9].

When it comes to competence brokering, it seems to be a diffuse definition. In our opinion, it is correct to say that competence or knowledge brokering is all about the same as the definition of technology transfer. That means good communication, problem formulation, and finding experts/researchers to solve the problem. The competence brokering is not entirely completed before the challenge and the problem has found its final solution and the solution has been implemented. More in detail an innovation broker according to the definition of Howells [3] is:

“An organization or body that acts as an agent or broker in any aspect of the innovation process between two or more parts. Such intermediary activities include; helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations.”

II. CHALLENGES, NEEDS AND OPPORTUNITIES

In both national and international studies, it is documented that 60-70 % of the challenges and needs of SMEs in different countries are related to products, processes and international marketing. Other studies also show that these issues are the most important priorities for SMEs, but not the only ones. Most companies have many challenges to be more competitive. The broker should initiate a meeting with the company to be acquainted, build trust and inform about current instruments and capabilities.

An important part of the company visit is the guided tour through the workshop: and to get the opportunity to see the production facilities and the products, and also to be introduced to relevant challenges and innovative ideas they may have. Experience shows that during the tour in the workshop there will appear several needs and requests. Upon reviewing the broker must assist in prioritizing and clarifying the needs for R&D and wishes the company has to go ahead in the development. It is during this phase the broker must discuss with the management and highlight relevant opportunities for the company, and give examples of successful use of R&D knowledge, and if possible already at that point of time make clear which R&D institutes or even which resource persons who could contribute. It also happens that ideas may be proposed by persons who know the industry and a company particularly.

If the company allows it, it is a great advantage to take pictures during the visit. These are good documentation when the broker shall discuss with the researcher to establish the content of the project. During the visiting tour in the workshop the broker should make attention. What the broker see indicates if there are good structure and order in all areas or not. In recent years, more and more companies focus on better efficiency in production, and it can easily be seen whether the company has challenges and needs within LEAN-based production, automation, and organisation. LEAN is much about attitudes, systems, methodology, and tools. This is a good basis and starting point for discussion with the management. Various methodologies and tools to become more efficient are on the agenda at many SMEs. Examples are to make use of and implement methods like 5S, SMED, Kanban, TQM, maintenance, and new knowledge in general, especially for the smallest companies. LEAN is characterised by: achieve less waste, better utilisation, continuous improvement and learning through strong and active involvement of the employees. In connection with requirements of energy efficiency stated in new technical regulations it has also recorded great interest for company projects, mainly within product and process development.

Where a project is not seen as a relevant mean or where the company meets other challenges, the broker can assist the company in other ways, or refer to other solutions or state programs. The broker can e.g. assist the company in establishing contact with qualified personnel from other parties than R&D institutes, like companies, suppliers (CNC, tools, robots, software, etc.) and international networks. The broker can also assist companies in writing applications for tax refund on research activities.

III. EXPERIENCE FROM A REGION

The region Innlandet, with more than 382,000 inhabitants, consists of Hedmark county and Oppland county, and is big in area (52,500 km²). Competence brokering is one of more policy instruments in Innlandet, and it has developed its own targets for the brokering. In 2014-2016 the target groups are SMEs in the business sectors manufacturing industry, tourism and bioenergy.

The target group for the study in this paper is the manufacturing industry in the Innlandet [4]. From the national database at Statistics Norway (www.ssb.no) is the total number of companies retrieved. A substantial overview of companies has been established in an own database, which currently contains about 1000 companies. Most of the companies belong to the woodworking, mechanical and food industry, and most of the implemented projects are indeed within just these three industries. For the manufacturing industry the target groups are companies that belong to industries within light metals, wood and foodstuffs. However, it is possible for companies within other sectors to take advantage of competence brokering and the financing tools. New target groups are now even inventors, entrepreneurs, incubators, innovation projects, Science Parks, and other regional knowledge environment. The funding sources are the Research Council of Norway, Innovation Norway, and the two counties. Each broker administers funding that can be used to finance the individual company projects. The use of this money has to be approved by the Norwegian Research Council, or by Innovation Norway. The brokers are well informed about other possible funding sources and financial tools.

From 2004 to present time, 291 innovation projects have been implemented within manufacturing industry in Innlandet. 17 projects are still running. 47 different research communities have been involved in carrying out the projects. 177 of these projects have been continued in other new bigger projects, and the number will increase. The experience from the region Trøndelag in Mid-Norway is about the same. In Figure 2, 3 and 4 next page the number and type of projects and industries in region Innlandet are shown.

Experience shows that 41 % of the projects are related to automation and streamlining the production. All these projects are implemented in companies dealing with woodworking, mechanical, food and plastic manufacturing, with the largest number of projects in the first two sectors, and in companies with more than 12 employees.

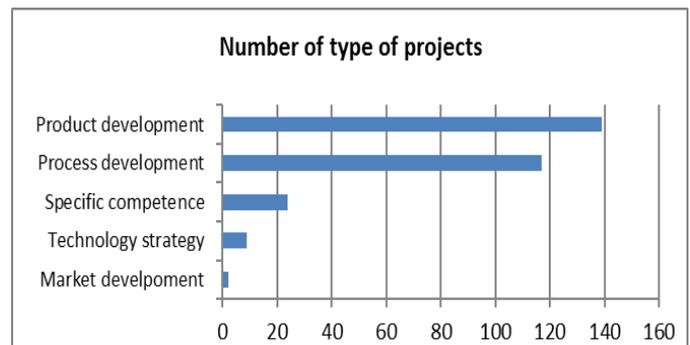


Fig. 2. Type of projects

An analysis of the 117 projects within process development shows the following type of classification:

- A. New concept, new process 24 %
- B. Efficiency/general automation 18 %
- C. Automation analysis/robotics 14 %
- D. Logistics/material flow 10 %
- E. Machining/method development 10 %
- F. Maintenance 9 %
- G. Continuous improvement 9 %
- H. Production management 6 %

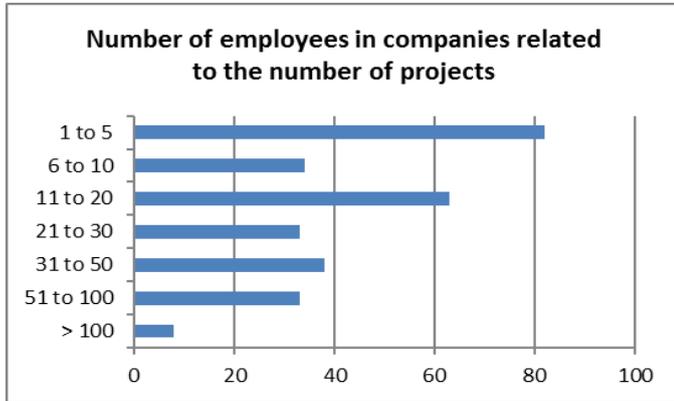


Fig. 3. Size of companies and number of projects

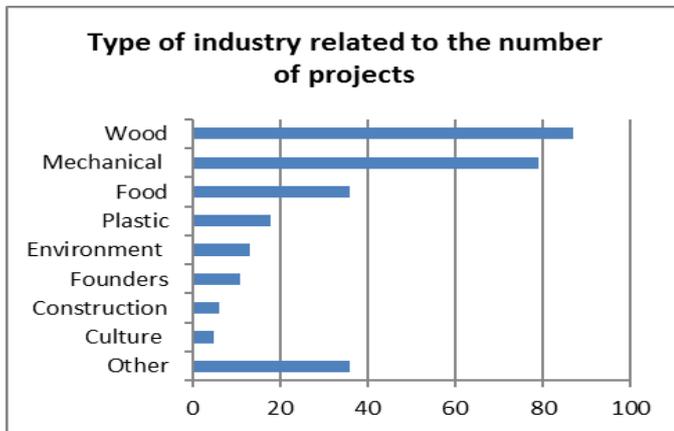


Fig. 4. Type of companies and number of projects

A. Cases and examples of projects

TABLE I. EXAMPLES OF PROJECTS/CASES RELATED TO PRODUCTION

Case	Project title	Type
1	Automatic inspection, handling and packing of elements in lockers	C
2	Efficiency improvement and automation in sawing	B
3	Automation in casting process	A
4	Increased productivity in the engineering workshop	B

5	Automatic assembly of utensils by use of robot	C
6	Develop new automatic lines for production of roof frames	A
7	Robotic welding of heavy steel constructions	C
8	Automatic packing of woodwork at the end of production line	B
9	Efficient production of elements for small houses	B
10	Automatic welding of special tubes	A
11	New methods for production of the PMMC alloy	A
12	5S methodology and PLI - Process Loss Indicators	G
13	Continuous improvement through effective 5S and maintenance	G
14	Automated process line for telescopic products	C
15	Automated packing of plastic products	C
16	Robotics in new production line for ventilation products	C
17	Production logistics with new technology	D
18	Management model for smart production	H
19	Automation analysis. Packaging tool for baby buggies in air transport	C
20	Optimal planning of the total production	H



Fig. 5. New automatic production line [9]



Fig. 6. Upgrading to automatic production line [9]

B. *Effects and success factors of competence brokering and technology transfer*

Looking at the effects of competence brokering, it is difficult to distinguish between the brokering itself (coupling and consultation), and the company specific projects that are being implemented. Results from a national evaluation of Research based brokerage showed that 94 % of the participated SMEs would like to cooperate with R&D institutions again (re-purchase), and 92 % of the participated researches would like to cooperate with SMEs again. Company self-assessment showed very good additionality of the company projects and research expertise, and also that the active role of the competence broker contributed to additionality [2].

The most important and necessary skills of a broker is probably to attain good trust with the company, work very close, be open-minded and able to see that a variety of innovations are possible, and that these are based on the needs of the company. It is important to use as much time as necessary with the company, and to accept that some ideas or projects are time-consuming to develop. The broker must be able to work in an informal and even "un-bureaucratic" way. Most of all, the brokers must have the will to develop projects to the best for the company, and be able to see the world from the company's point of view. Further on it is important to have access to funding to be used for the projects. If it turns out to be too complicated, time-consuming or uncertain whether funding will be given or not, it will often spoil the motivation for the companies.

During master studies in Management and Technology [5] last year three students have completed in-depth interviews in SMEs which have and have not participated in the program. The main finding is that there is a clear difference between these companies. The studies show that some companies have little or no knowledge of R&D at all, and they have none in their close network that has been associated with R&D institutes. They are missing an external actor they can consult with and verify their possible collaboration with a R&D institute to achieve the most relevant knowledge. Due to this lack of support, the companies also may feel that it is too risky to collaborate, and they do not know what the collaboration can lead to and what they can expect and achieve from it. Different perspective and understanding is also considered to be barriers for this kind of collaboration.

Although there is a certain degree of scepticism regarding collaboration with a R&D-institute in some SMEs, the studies show that competence brokering is a determining factor in order to initiate and start a project. The role of a competence broker is by the companies seen as a reassuring supporter in the collaborative process. Interaction and communication do affect the cooperation. Good relation with the researcher is considered as a central finding, and face-to-face contact and face-to-face communication is considered important for establishing and strengthening good relationships. This affects the effectiveness of knowledge transfer and the innovation process in the project, and it is through such contact with the researcher that many of the companies increase their knowledge [6]. Face-to-face contact when the broker is visiting

the company is important for building trust for initiation of projects and the knowledge transfer to the company.

The studies further show that the SMEs and R&D-institutes which have been collaborating in the initial competence brokering projects, continue to involve in further, new organizational collaboration. It is clear that the Board of these companies consist of several external members who are well engaged in the company and contribute in decision to start projects. The studies also point out that the competence broker contributes to expand the companies' network. This indicates the long term positive effect of competence brokering [5].

Feedback from the case interview of companies and findings also shows:

- Education and background affect much if the company is open for cooperation
- Relationships, existing networks and knowledge of R&D environment are crucial for participation in projects
- The idea for a project must be well rooted in the company
- Companies with an engaged administrative board, also with external members, are more focused on cooperation with R&D-institutes
- After finishing a project there has been a change in attitude in the companies when it comes to the benefits of cooperating with R&D institutes and universities
- Competence brokering and technology transfer gives valuable input of knowledge to the companies
- Solving company specific problems with external knowledge gives more rapid and better results
- The broker is important in the project development inclusive finding the right researcher

IV. INNOVATION IN NETWORK

One may wonder whether these company specific projects based on competence brokering as separate projects in collaboration with a researcher will have a better effect in a company if they are implemented in regional innovation networks with more participants? To what extent is such a network viable and effective over longer time? Will the relations fall away when the network project is finished? What happens next with regard to further cooperation with R&D institutions, and also between the companies themselves [7]?

An innovation concept for teamwork, knowledge management and technology transfer was developed by SINTEF in the middle of the 80s, and has evolved over many years up to present day. It is based on the triple-helix model with close cooperation between selected companies, R&D knowledge and public instruments for financing. It is designed for SMEs who want to expand and strengthen their innovation abilities. During the last 30 years more than 50 such innovation networks have been implemented by SINTEF, where more

than 400 companies have participated. Experience shows that the concept contributes to establishing many and large projects as well as new arenas of cooperation.

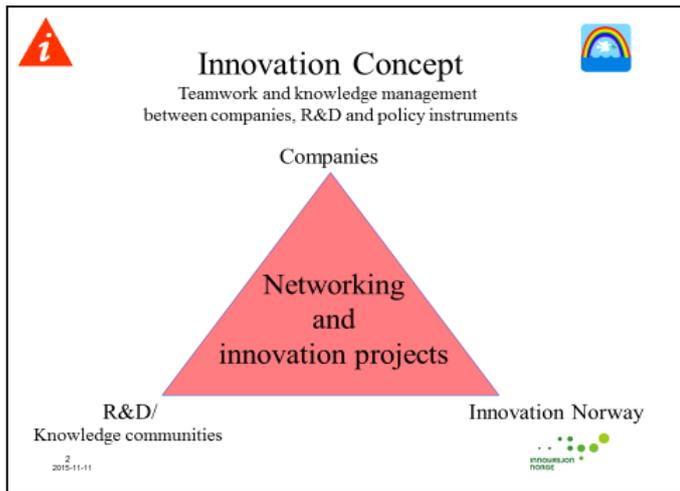


Fig. 7. Innovation network concept

Normally 8 industrial SMEs participate in the technology development process lasting for a period up to 18 months. The project consists of 5 mandatory seminars and one following up seminar with participation by the management level in the companies at all seminars. A technology-oriented researcher (mentor) from a R&D institute, university or relevant knowledge environment, and a process consultant guide each company. In the intermediate periods, the companies work with the researcher and the consultant on matters such as technology audits, strategic planning, company specific challenges, knowledge and competence building, marketing, definition, development and implementation of technology oriented projects, and collaboration with the other companies. The conceptual model is divided into two steps. (Figure 8).

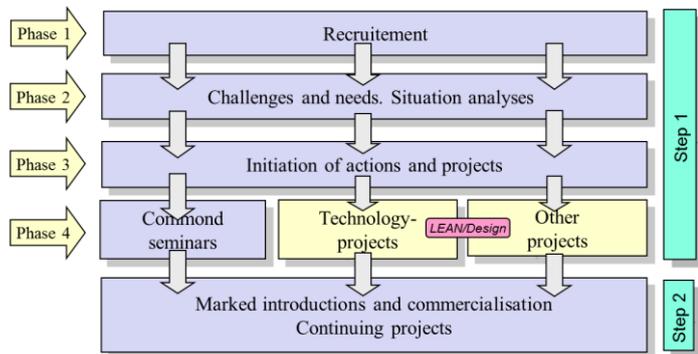


Fig. 8. The network project model

The first phase in Step 1 is related to mapping of companies, normally 15-20, who are considered to be potential candidates for participation in a new network. In this phase competence brokers are used for visiting the companies to provide and obtain facts and information, identify current needs for innovation and technology development and to visualize the possibilities. When 8 companies have decided to participate a report for description and analysis of the present situation in the company is worked out (Phase 2). This forms the basis for

the content of the main technology project, and the selection of the most appropriate researcher to work with the company.

Phase 3 is dealing with initiation of relevant activities and the development and initiation of the projects. As previously mentioned this will be in cooperation with the researcher or/and other expert knowledge from a relevant R&D institute or university, where student resources also can be used. The project description itself is prepared in common by the company, the competence broker and the researcher.

In Phase 4, the longest phase and maybe the most important ones, the 5 seminars, the selected innovation project and other projects are implemented. Step 2 is entirely related to marketing and commercialization, and new continuing projects. A following up seminar is conducted at the end.

The concept facilitates each company to work in close cooperation with each other and also with several technology-oriented researches and even students guided by the process- and project management in the given period. See Figure 9.

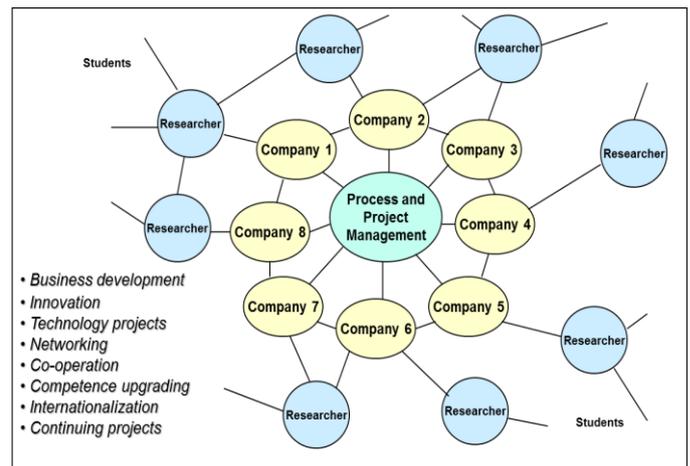


Fig. 9. The network concept

The main focus in the concept is business development, innovation, technology oriented projects (product/process), networking, co-operation, competence, export and continuing projects. Some relevant reflections in this respect are: Do the concept generate more knowledge for the companies compared to single projects? Does the concept develop knowledge on how innovation networks can lead to better results for the participating companies, and does it generate knowledge about how new cooperation models can be developed?

V. THE RELATION COMPANY AND RESEARCHER

Based on the preliminary feasibility study in the two described concepts, a researcher who possesses expertise relating to key challenges to the company is selected. Past experience shows that companies are very satisfied with this method, and that it has been crucial for achieving good results. Some companies want a specialist within a specific area (technology, automation, robotics, material technology, design, etc.) that is strategically important for the company, while others see the benefit of a generalist and good interlocutor covering several fields that the company is concerned with and where it has its challenges.

Use of the same researcher throughout the whole period is a clear advantage for continuity (the network concept). Certainly, such people may also be trained in more process-related working, focusing heavily on innovation and technology. This means that such a mentor can assist companies with other tasks within the overall enterprise development and strategic planning, idea generation, project initiation and otherwise daily troubleshooting. Through this the project becomes an establishment of a long-term relationship which will last far beyond the period of the network project itself.

During the recruitment phase it usually emerges that the companies have many other challenges and needs than to introduce new technologies and market development. Design, organization, management, knowledge, strategy, human resources, recruitment and financial issues are such areas. To meet the total requirement, resources from various R&D institutes, universities, suppliers, other businesses and public entities are used, also at the seminars. This contributes to creating new external contacts, networking and learning.

VI. CONCLUDING REMARKS

The competence brokers have to obtain a good overview of the business life and the companies in the region where they are working. The broker shall conduct outreaching activities in the selected companies, orientate and become familiar with them and especially be able to discuss the challenges, needs and desires they may have. Furthermore, the broker shall inform about relevant opportunities and policy instruments, and have the ability to outline/describe the content in a development project regarding technology (products and processes). Then the task is to find one or even more appropriate researchers at R&D institutions or a knowledge environment that matches the challenge the company has. In other words, the competence broker shall initiate, implement and monitor a project that has a certain level of R&D content and is something new for the company as to raise it further and help it become more competitive. With this setting the broker must have good overview and be updated when it comes to the business life and companies in the region, technology, the same as it comes to the scope of expertise and area of knowledge at the R&D institutions and also the relevant financial instruments for financing the projects. Competence brokering is a tool to enhance cooperation between SMEs, R&D institutions, universities and other R&D partners due to:

- Easy access for SMEs to R&D knowledge
- The broker finds SMEs and researchers
- Proactive way of working for visiting SMEs
- The broker communicates with both the SMEs and the institutes
- Finding right researcher for the single project – also national and international institutions

- The brokering leads to knowledge-/technology transfer and projects in SMEs
- Company-specific projects in SMEs seem to have a greater effect than individual separate projects. Some reasons for that is that more people with different knowledge are involved, and projects are also larger
- The brokers are supporting the development of the project applications
- The timing. There are no deadlines for applications
- Financial packages give necessarily motivation to start the cooperation
- The researchers receive money which motivates to complete the projects
- Successful cooperation must start at the personal level

The above description confirms earlier noted references: A study conducted by Lee et al [8] suggests that when it comes to collaboration for innovation, SMEs prefer research institutions to other firms for strategic alliances, at least to a certain extent. Competence brokers play a significant role in establishing this kind of cooperation.

Though the old concepts for competence brokering and technology transfer still work very well, they have been evolving more or less over time. Further developments of these programs and founding must take into account the constraints and opportunities inherent in the rules of the state subsidy (EU/EØS), and accordingly make use of students, and competence brokering even in public sectors.

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