

*SNS*

Centre for Business and Policy Studies

*UCER*

Umeå Centre for Evaluation Research

Prestudy for the  
**Evaluation of the KK Foundation's  
Knowledge Exchange Programme**

Literature review  
Programme description  
Evaluation proposal  
Comments from IAG

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**June 1998**

## Preface

The Foundation for Knowledge and Competence Development (the KK-Foundation) has initiated a separate, multi-year programme to foster the transfer of knowledge and competence between industry, higher education institutions and research institutes. The programme consists of seven sub-programmes, most of which are still at an early stage of development. The KK-Foundation has elected to involve external expertise in order to follow and evaluate the programme from its very beginning. The Center for Business and Policy Studies (*Studieförbundet Näringsliv och Samhälle*, SNS) and the Umeå Centre for Evaluation Research at Umeå University (UCER) agreed to conduct a pre-study, which would form a basis for the Foundation's decisions concerning the evaluation. This report documents the results of the pre-study.

The report consists of the following four parts: an overview of existing knowledge on university-industry cooperation; a description of the KK-Foundation's programme for knowledge transfer; a proposed evaluation plan; and finally the comments of an international expert group linked to the pre-study. Preliminary versions of this report have been discussed both with a separate reference group composed of representatives of industry and academia, as well as with project leaders within the knowledge transfer programme. The report has also been deposited with the KK-Foundation, as agreed.

UCER has had primary responsibility for writing the first three sections of the report. Anders Hanberger compiled the overview of existing knowledge; Joel Wikström described the programme, and Clas-Uno Frykholm developed the evaluation plan. Responsibility for the reference group and for the international expert group has lain with SNS. We are however jointly accountable for the report as a whole.

Stockholm and Umeå, June 1998

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## **Co-operation between industry and higher education**

### **Government, university and business in collaboration**

The idea that higher education could promote technological and industrial development is still fairly new. The first steps in this direction were taken during the inter-war years in the USA, and in Sweden in the early 1960s. However the need to utilise scientific knowledge in industry and policies to promote its implementation have much older roots. In many countries, governments have sought to encourage the development of knowledge that would be beneficial to industry. Most of these measures, however, took place outside the universities. In Sweden, the foundation of polytechnic institutions and other types of industrial research organisations took place at a relatively early stage. In 1919, for example, the National Academy of Engineering Sciences (IVA) was founded.<sup>1</sup>

However it was not until the mid 1970s that the government and the world of higher education adopted an active, co-ordinated research policy.<sup>2</sup> National research policy consisted mainly of disconnected measures to support R & D within sectors such as defence, university research and industrial research. The establishment of the Board for Technical Development (STU) in 1967 was an important measure in support of industrial research.

In recent years, there has been a marked increase in interest in different types of R&D co-operation. A number of interested parties now appear in this arena, for different reasons.<sup>3</sup> Government research policy during the 1980s and 90s has become more decentralised and more oriented towards the support of sector research, frequently in close co-operation with business.<sup>4</sup> The needs of industry are nowadays given a much greater priority.<sup>5</sup> Government, industry and higher education are now trying to find new forms of research collaboration that will help promote economic and technological development.<sup>6</sup>

Henry Etzkowitz and Loet Leydesdorff (1997) have produced a model that examines the development of technology and infrastructure in the area of research and development. A triumvirate of interested parties – government, industry and universities – that are mutually dependent on each other in our present day learning society create different types of meeting places and networks in order to establish a common platform

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<sup>1</sup> Sörlin, 1996, pp. 11 et seq; pp 52 et seq.

<sup>2</sup> Premfors, 1986, pp.11 et seq.

<sup>3</sup> NUTEK 1996 b, p. 41 et seq; Etzkowitz and Leydesdorff, 1997

<sup>4</sup> The government attempted to centralise its R&D policy in the mid-1970s. This was a period when the public sector was subject to a highly rationalistic planning philosophy (Premfors 1986, p.43). In practice, however, the government did not succeed in establishing overall control of research in the various sectors.

<sup>5</sup> NUTEK, 1996 b, p.45

<sup>6</sup> SOU 1997:16, Sutz 1997

for the development of new ideas that will further economic and technological development. These national knowledge networks are part of what may be termed a “global knowledge economy”. In this model, the actors (institutions) are considered as equals. It emphasises taking account of the different motives that the various actors have for participating in collaborative ventures and their varying expectations regarding the possible results of such co-operation. According to the authors, technological innovation will be developed within the newly-formed institutions where the three principal actors collaborate. It is there rather than in the existing institutions that a “knowledge-based reconstruction” will provide the conditions for the growth of production and employment.

Now that Sweden is a member of the European Union, part of the government's research funding is allocated to Brussels. The Europeanisation of research policy has led to increased competition for the available research funds. The EU is now participating in the R&D arena. Its policy is to support research that is trans-national in character and designed to strengthen European economic interests.<sup>7</sup> The interests of the European Union and its regions will be therefore given preference over national interests. A stronger EU, together with active local and regional interests will increase the number of participants in the process. This may lead to conflicts regarding objectives and policies at different political levels as well as between private and public interests.

Analyses of the relationships between universities and the business community in recent years show that the Swedish experience is different from that of other countries. In Sweden, universities and industry have developed independently, whereas in other countries, such as the United States, the same institutions have developed close relationships. American universities have welcomed economic support from the business community. Leading universities such as Harvard, Princeton and the University of California have received major funding from industry, especially in the area of military industrial research.<sup>8</sup> In Sweden, ideological barriers have prevented this type of collaboration. Many researchers have also been concerned that a dependence on industry for research funds would lead to a loss of academic freedom. This view is still prevalent among many researchers in Sweden.

The ideological barriers to co-operation between business and industry have undoubtedly been reduced in recent years, but fundamental differences in perspectives cannot be ignored when seeking to establish bridges between the two cultures. Indeed the coming evaluation of the results and benefits of the KK Industrial Research Schools Programme should recognise that success or failure in the field of research collaboration may be assessed in terms of different criteria prevailing in the two “cultures”. We will return to the question of the criteria and indicators that should be used in an evaluation of the KK Industrial Research Schools Programme.

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<sup>7</sup> Official government document Ds 1994, p.13

<sup>8</sup> Sörlin, 1996

## **The university in economic and social change**

Ever since the Middle Ages, the primary role of the university has been to maintain the existing social and economic order. The idea that universities (and schools) should preserve the best of a culture, act as a support for religion, good manners and customs is a conservative view that should not be confused with those of political conservatism.<sup>9</sup> However the social order which the university has sought to protect has changed dramatically over time. Within the church and the expanding university, a European spiritual community was established during the Middle Ages. The Swedish seats of learning (the “studia” and the cathedral schools) were also part of this growing European community. Not only centres such as Linköping and Lund but also smaller communities such as those in Skara and Skänninge acted as Swedish centres and meeting places in this medieval European world of learning.<sup>10</sup> A medieval or craft guild heritage still continues in today's academic world, with its emphasis on testing academic performance and a system of final exams as the production of a *masterpiece*. However this medieval European community without borders began to break up under the pressure of developing nation states. The nationalisation of the universities also led to barriers being built against the outside world. With the exception of a certain amount of research, Swedish universities can be said to have isolated themselves from the outside world from the seventeenth century until the latter part of the twentieth century. Such isolation was also seen as a problem right up to the official government enquiry into internationalisation in 1972.<sup>11</sup>

The responsibility of the university in today's knowledge society is to develop or change rather than preserve society. During recent years, the principal task of higher education has shifted towards the development of vocational education rather than its traditional support for academic learning. There has also been a tendency to develop an interdisciplinary approach to learning at the undergraduate level and within postgraduate research.<sup>12</sup>

Current university research not only has the task of pursuing academic education, the growth of knowledge and a critical appraisal of economic and social development in different areas of society, it is also designed to contribute to the defence of the nation and to support business innovation, regional economic development and, through welfare agencies, to solve some of our pressing social problems.<sup>13</sup> Towards the end of the twentieth century, great hopes arose that, with the aid of research and development, society would be able to improve its economic and technical performance. Encouraged to take on a more active role, the university - together with industry – would animate economic and social change.

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<sup>9</sup> Liedman 1997, p.215.

<sup>10</sup> Sörlin 1996, p.31 et seq.

<sup>11</sup> Ibid, p.36.

<sup>12</sup> Franke and Frykholm, 1997.

<sup>13</sup> Premfors, 1989; Stenberg and Marklund, 1994; Fossum 1996; Kasemo, 1996; Sörlin 1996; Liedman 1997; Wickbom 1997.

Nevertheless it can still be argued that the universities retain a socially conservative role in the sense that they seek to maintain and strengthen the prevailing social order (i.e. a mixed economic system where the state and the market are mutually dependent on each other). The university operates within the framework of a global market economy and a political system that is no longer confined to the nation state. It is to this social order that the university contributes.

Network is a concept that has been used during the 1980s and 1990s in relation to both personal and organisational meeting places between for instance universities and industry. Co-operation through networks may take the form of temporary or permanent relationships. Personal contact networks change and are often reactivated in relation to different problems and requirements. When organisations become part of networks, some form of formalised co-operation usually results. 'Nordnet' is an example of a network between researchers at the University of Halmstad and industry concerned with the development of work organisation in the engineering industry.<sup>14</sup> Another example of the regional mobilisation of knowledge is provided by the establishment of the Centre for Education and Research in the Social Sciences (CUFS) in northern Sweden. This centre is based on a network comprising Luleå Technical University, the local authorities in Norrbotten, the regional council, and the county administration which meets for the purposes of research co-operation and the exchange of knowledge.<sup>15</sup> A third example of a more formalised form of network co-operation is provided by the Centre for the study of human society, technology and organisation (CMTO) at Linköping University. This network supports research within both the private and public sectors and facilitates contacts and the exchange of knowledge between university and business. The construction of networks in the form of "centres", for instance, may be viewed as a complement to the R&D work being carried out in the universities and business research laboratories. At the same time it is a sign that existing institutions are not able to adjust to coping with the needs and challenges that the key actors consider to be most pressing. By creating new institutions for research co-operation, it is not necessary to try to get the existing institutions to adjust to the new challenges.

Around Europe and in Sweden, there are a local and regional efforts to utilise and develop knowledge and competence. However this process of mobilising knowledge and competence in which universities and colleges inevitably play a leading part may also give rise to conflicts regarding the role of the university in social change. Representatives from the older established universities are often to be heard raising a warning voice about the dangers of spreading research resources too thinly among too many interested parties. There is no such comparable conflict at the undergraduate level between the established universities and the new growing regional universities.

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<sup>14</sup> Gustavsen and Hofmaaier 1997, pp.36

<sup>15</sup> Information on current research co-operation between Luleå Technical University and industry can be obtained electronically ([cufs@ies.luth.se](mailto:cufs@ies.luth.se)) or by telephone (0920-913 61).



## **International perspectives on industry-higher education co-operation**

Most countries have established some form of institution for the development and exchange of knowledge between the business sector and higher education. Research institutes, science parks and innovation centres are all examples of institutions that operate in a newly created area where business and university can meet.<sup>16</sup> However a comparison between the research institutes of different countries indicates substantial differences between countries.<sup>17</sup> Above all, there is a difference in relation to business climate and historical traditions. The research carried out tends not to follow any specific pattern. Certain institutes specialise in a certain type of technology while others focus their efforts on specific target groups, such as small and medium-sized companies. A common feature however is that these institutes conduct applied research and do not compete with the basic research carried out by universities and business and that a significant proportion of the costs are borne by companies themselves.

In Germany there are numerous examples of close co-operation between business and university. There are for instance around 50 research institutes (Fraunhofer institutes) employing a staff of 8,500. These institutes were created after the Second World War in order to train specialist engineers and to facilitate technology transfer from university to business. After the fall of the Berlin wall and the reunification of Germany, new research institutes have been established in eastern Germany. A large proportion of the costs involved in the founding of these new research institutes are met out of public funds (federal and, to a lesser extent, from the provincial governments). The institutes also try to persuade the business sector to take on as much of the financial responsibility as possible, normally around 30 per cent. About half of the staff are researchers and technicians while a slightly smaller proportion are either doctoral students working on a project basis or undergraduates. The heads of the institutes are at the same time professors at nearby universities. The institutes are evaluated every fourth or fifth year and if they are considered to be successful, they are allowed to continue their operations.<sup>18</sup> German companies place a higher value on these national research institutes as a source of knowledge in comparison with for example companies in other European countries.<sup>19</sup>

In the United Kingdom, the earliest and largest programme for research and education co-operation between university and business is the so-called CASE scheme (Co-operative Awards in Science and Engineering).<sup>20</sup> This co-operation was established already in the mid-1970s and covers both natural science and social science subjects.

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<sup>16</sup> NUTEK 1996a

<sup>17</sup> *ibid*; Rush and Hobday 1996

<sup>18</sup> SOU 1997:37

<sup>19</sup> NUTEK 1996a, p14.

<sup>20</sup> The description of CASE is based on a conversation with Luke Georgiou during a discussion of the pre-study in Stockholm on April 23<sup>rd</sup>-25<sup>th</sup>. 1998 and the report on the international evaluations written after the Stockholm meeting (Etzkowitz et al. 1998).

At present there are about 3 700 students involved in some form of CASE project and about 1000 new grants were made available during the academic year 1996/97.<sup>21</sup>

Research co-operation is based on a common research subject which both university and business (including the public sector) find interesting. The research projects are supervised by a project group consisting of representatives for both university and business. CASE provides the students with an extra grant in addition to the research council grant and the opportunity to work with a research problem in a realistic environment. There are three motives for business participation in these research projects. The economic support from CASE contributes to holding down research costs which creates the opportunity for more ambitious enterprises. It also offers a good basis for the recruitment of skilled staff and an opportunity to construct a more permanent co-operation with the university. For their part, the universities receive a certain grant from CASE and at the same time gain experience that they can make use of in their contacts with the business community and in attracting and recruiting able students.

There are many variants of CASE. There are individual doctoral student projects and more institutionalised co-operation where doctoral students are based in a particular centre. The latter include the programme "Postgraduate Training Partnerships" where students are based in eight research and technology organisations and the programme "Total Technology" where four academic centres are concerned with seeking to raise the skills of young engineers. Not all of the programmes are aimed at the completion of a Ph.D. Several are completed following the Masters exam while others seek to raise the quality of education without having the goal of an examination. No systematic evaluation of CASE has been carried out although certain aspects of the programme have been evaluated. It is generally thought to have been successful.

In the UK, a more general model, LINK, has been used to further research co-operation between companies and research groups at universities and research institutes. The government has been responsible for up to half of the research costs involved in the project. The model has been evaluated positively.<sup>22</sup> Furthermore, the Research Council in the UK has devised a system of payments which provides funds when researchers co-operate with business. In this case, it is assumed that a researcher has secured basic finance from a company before applying for a ROPA award (Realising Our Potential Awards)<sup>23</sup>

In the USA, different types of research centres have become established within universities. These have tended to straddle different disciplines in order to develop inter-

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<sup>21</sup> About one third of the research students who took part in the CASE co-operation were financed by the ESPRC (Engineering and Physical Science Research Council) and the BBSRC (Biotechnology and Biological Sciences Research Council).

<sup>22</sup> Ibid, p18.

<sup>23</sup> The ROPA awards have existed since 1994 in the UK. In order to apply for this award, the company has to provide basic finance totalling at least Skr. 380 000. In 1996 over Skr.200 million was allocated to this type of support for industrial research (NUTEK 1996a, p18)

disciplinary competence. By establishing research centres, it may be possible to reach a greater critical mass than would have been possible by conducting research on the basis of a single discipline. At American research centres, there is a long experience of research aimed at developing knowledge and the transfer of knowledge between the two cultures. Massachusetts Institute of Technology (MIT) is one of the universities that started early and has a long established co-operation in the field of creating and disseminating knowledge with the business community. This relationship was founded after the Second World War when an inter-disciplinary research laboratory for electronics (RLE) received financial support from the Pentagon. In addition to skills in electronics, the inter-disciplinary RLE also comprised skills in languages which was considered to be highly beneficial. In 1990, there were more than 1000 research centres in the USA where university researchers co-operated with the business community. Almost three quarters of the business community's funding of university research in 1990 was allocated to such research centres.

One example of particular interest in this context is the programme for the training of industrial Ph.D students at the Rensselaers Polytechnical Institute (RPI) in the USA. The programme has been developed together with General Electric. Employees at the company's R&D laboratories are able to work on their own Ph.D projects on a part time basis. In this way, the industrial Ph.D. students are able to keep a foothold within industry at the same time as they are members in a group of academic researchers. This programme is the result of many years of co-operation between General Electric and RPI. Many of the professors at RPI previously worked within General Electric. At the same it was customary for the Ph.D. graduates at RPI to work for General Electric on completion of their studies (Etzkowitz et al 1998).<sup>24</sup> Within this research co-operation, means of protecting company secrets have been developed by, for instance, delaying publication and establishing routines for the release of secret material.

The experience of R&D co-operation between companies in Japan is reminiscent of the organisation of this type of co-operation in Sweden.<sup>25</sup> A group of companies start with the identification of a technical problem which is considered to be a problem common to the group. Subsequently the companies devise a programme in order to try to jointly solve the problem. However in contrast to the Swedish company researchers, the Japanese company researchers and technicians carried out most of the work themselves. The Japanese government with the help of MITI (Ministry of International Trade and Industry) have stimulated the development of R&D co-operation with companies. MITI has invested heavily in major long-term programmes that sometimes extend over ten years. The overriding aim has been to build up a common base of knowledge and an exchange of information between companies that reduces uncertainty when companies invest in their own projects. This type of co-operation has also

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<sup>24</sup> Further information of the doctoral programme at RPI may be obtained by visiting their web site at <http://www.ecse.rpi.edu/academic/grad-aid.html> 1996 01 17). However updating the site does not appear to be one of its strengths

<sup>25</sup> NUTEK 1996 a, p.26

demonstrated that it stimulated competition and a willingness to test new technologies. Foreign companies may now participate in Japanese R&D programmes. For instance Pharmacia Biotech is participating in two programmes. Opinions differ on the value of the government research programme for Japanese industry. Its importance for company's central activities was presumably greater 10 –15 years ago. However, the programme is still considered to be of major importance in micro machine technology.

The Japanese university has long had a limited role in industry-related research. However nowadays, research is being conducted by company groups and research teams at the university. Part of this research is financed by the Ministry of Education. Ericsson is participating in such a programme together with Japanese companies.

In one important respect, Japanese companies differ from companies in other countries. They are to a much greater extent willing to send their researchers and technicians to co-operative research ventures between the business community and the university, both in Japan and abroad. Analysts are now warning that Japanese companies in the form of their more or less life-time employed research staff may be in the process of acquiring a competitive advantage over American and European companies.

Research and development consortia are another established of co-operation between university and business in Europe, Japan and USA. The aim of such consortia has been to raise the level of skills in industry and promote technological development. Raymond Corey who studied American R&D consortia points out that the formation of consortia often occurs in conjunction with some form of crisis.<sup>26</sup> The visionaries within industry or the government have then experienced a great need to act and encourage new hope. A "solution" to the crisis has been to establish consortia. In this context, there are usually a number of interested internal and external parties. Most of them are also closely associated with public institutions on different levels. From the early 1970s, the consortia have contributed to the development and dissemination of technology to many companies. They operated as hothouses for economic development and thereby strengthened the competitiveness of American industry. This has been done without the curtailment of competition or forcing an unwanted national industrial policy on industry.<sup>27</sup>

Some form of industrial Ph.D. student model is to be found in most countries which may be seen as a further type of co-operation between higher education and the business community. The idea of the industrial Ph.D. student is to try to raise the level of skills in a company and allow the individual doctoral student to act as a bridge-builder between the two cultures. A project agreement is usually drawn up between the research student, company and an institution. The Ph.D. students carry out one or several industrial research projects at the same time as they receive tuition and supervision at the

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<sup>26</sup> Corey 1997

<sup>27</sup> *ibid*, p148 ff

university. Certain projects lead to a Ph. D while others are shorter and are conducted at a lower academic level.<sup>28</sup>

During recent years, industry in several OECD countries have increased their public funding of industry-supported research in both the public sector and universities. A major reason for this growing support is that government itself is unable to fund this research. The increased interest shown by industry in research co-operation is largely attributable to the fact that high-tech and research-intensive companies are considered to have the best opportunity to succeed internationally.<sup>29</sup> As technical change increases the demands on companies, it becomes essential for companies to learn to take advantage of these new opportunities. It is no longer possible for a company to develop competitive products while at the same time maintaining a passive approach to technical change. Today high levels of technical skills and a declared ambition to keep abreast of technology are essential for international competitiveness.<sup>30</sup> However industry is unable on its own to meet the educational requirements to raise the level of technical skills (research education) or advanced research. Hence there is a mutual need to stimulate and develop research co-operation between the different parties.

Research reports and the use of personal contacts have been the principal sources and methods used by industry to gain access to public research. The personal contacts have been necessary in order to gain "silent knowledge" which could not be obtained in other ways.<sup>31</sup>

Indeed one of the underlying motives for research schools and other similar types of establishment is to establish an exchange of knowledge between higher education and the business community. Faulkner and Senker argue that research co-operation must be first of all established in areas where there are good opportunities for mutual exchange. This does not mean that the short term projects should be given priority. Their recipe for stimulating the flow of knowledge on different "research fronts" is to create many meeting places and channels for research co-operation.

### **A Swedish perspective on industry-higher education co-operation**

In relation to GDP, Sweden tops the R&D league table.<sup>32</sup> Above all it is the major international business corporations (Ericsson, Volvo, ABB, Astra etc.) that are responsible for expenditure on research and development. The latter has tended to increase while research in higher education stagnated in the early 1990s. In comparison

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<sup>28</sup> For further information see "Industrial Ph.D. student", p.11

<sup>29</sup> Faulkner and Senker 1995, p12 ff

<sup>30</sup> Stenberg and Marklund, 1994, p.58

<sup>31</sup> Faulkner and Senker 1995

<sup>32</sup> NUTEK 1996 B, p.21; SCB 1996.

with many other OECD countries, a substantial part of Swedish industry is would appear to be technologically specialised and competitive. However the technological resources are unevenly spread. A third of all industrial employees work within companies that do not have any university graduates on their staff. Moreover in certain parts of industry, expenditure on R&D has declined since the late 1980s. There are important exceptions, however, such as in the telecommunications and pharmaceutical sectors.

The principal concern of many analysts today is that innovation within Swedish industry and the diffusion of this innovation from the high tech sectors is worse than in many other countries. Furthermore there is a concern that the research at universities and research institutes is not on a sufficient scale.<sup>33</sup> The gap between the research carried out in the universities and the R&D of the industrial sector has been too large.<sup>34</sup> As was pointed out in the official government report on "Co-operation between higher education and business", there are shortcomings in the present forms of co-operation. It is against this background that different attempts have been made to find new forms for the exchange of knowledge between universities and the business community. Naturally the government hopes that the development of industrial research will lead to economic growth that will enable Sweden to maintain and hopefully develop its standard of welfare.<sup>35</sup> The view of many analysts is that if Sweden is going to be able to assert itself as an industrial nation, R&D will have to be better organised. In particular, the exchange of knowledge between university and business and between large and small companies will have to improve.

As much as 85 per cent of publicly funded research in Sweden is carried out in the universities. Countries such as France, Japan and the USA<sup>36</sup> have decided to invest a similar proportion of their funded research outside the universities. This type of imbalance may make it difficult to have a creative exchange of knowledge between university and business.

Another factor that may complicate the diffusion of knowledge is that the universities and business have basically different requirements. For the universities, external activities come in third place behind undergraduate education and research. It is when the external activities strengthen these two major functions that the conditions for research co-operation exist. Industry's collaboration with business has been largely characterised by pragmatism. Companies that have wished to benefit from research findings have sought out expert knowledge all over the world irrespective of whether it is found in or outside the universities. Generally speaking, companies have not been particularly interested in developing research institutions together with the universities.<sup>37</sup> The exceptions are the major business corporations and organisations that represent

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<sup>33</sup> Stenberg and marklund 1994, p11 ff.

<sup>34</sup> SOU 1996:70

<sup>35</sup> Cf SOU 1997, p.37

<sup>36</sup> Sörlin 1996, p. 62 ff.

<sup>37</sup> Industry' needs are primarily geared to obtaining well educated staff, help with the utilisation of research results and access to skilled problem solving.

business interests which can work in a more long term fashion and with long term research co-operation.

In Sweden, there are currently about 25 industrial research institutes actively engaged in applied research. These institutes differ from each other. The industrial microelectronic centre (IMC) carries out research at the component level while Sweden's Testing and Research Institute (SP) is concerned with basic research in the area of test and measurement technique, and applied research into the technical evaluation of material and products.<sup>38</sup> In January 1998, the Swedish IT institute AB was formed, an institute with a clear Swedish profile within the area of applied IT research.<sup>39</sup> The government accounts on average for 30 –35 per cent of the costs of the industrial research institutes.<sup>40</sup> The KK foundation currently takes an active financial part in helping to bring about a restructuring of a number of these industrial research institutes. The objective is that the institutes will be able to better act as a bridge between the universities and business in order to provide a more efficient basis for the strengthening of business competitiveness.<sup>41</sup>

The Swedish National Board for Industrial and Technical Development (NUTEK) which is one of the principal actors in this area has sought to promote R&D co-operation between universities and the business community.<sup>42</sup> In 1990, NUTEK and the Natural Science Research Council (NRF) set up "material consortia". Drawing on international experience, these consortia have sought to promote co-operation between university and industry in the field of advanced material technology.<sup>43 44</sup> These eleven consortia have been evaluated three times by international teams of experts. Several of them are considered to be world class. They have succeeded in establishing bridges between the worlds of higher education and business. Several of these consortia also have a potential to develop this co-operation.<sup>45</sup>

During the 1990s, NUTEK has also sought to establish direct contact with small and medium-sized companies in order to increase their awareness of current research. Since 1992, NUTEK has also initiated a new form of research co-operation between industry and higher education – skill centres. This type of co-operation, largely based on American and German experience, provides funding for research posts, industry-based doctoral studentships and staff exchanges. Eight companies have come together along with a university and NUTEK to form skill centres. All in all, 28 skill centres have been

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<sup>38</sup> [www.sp.se](http://www.sp.se), 1998-04-08.

<sup>39</sup> At the outset, the following institutions were included in the Swedish IT-institute: Swedish Institute of Computer Science (SICS), Svenska Institutet för Systemutveckling (SISU) and the Institutet för Medieteknik (IMT). The KK foundation has allocated S.kr. 200 million for the development of new applied areas at the Institute during the initial period.

<sup>40</sup> SOU 1996:29

<sup>41</sup> The KK foundation has participated in the restructuring of the Institutet för Optisk Forskning (IOF), AB Trätek, Sik – Institutet för Livsmedel och bioteknik and YKI

<sup>42</sup> NUTEK 1996 b, p.67 ff.

<sup>43</sup> Corey 1997

<sup>44</sup> NUTEK 1996 b, p.79 ff

<sup>45</sup> NUTEK 1995; NUTEK 1996 b, p 80

established of which 19 have been evaluated by an international evaluation team.<sup>46</sup> The quality of the work carried out and the motivation shown by both research students and the participating companies have been of a high standard. The only criticism of this project has been the lack of female participants and the insufficient attention given by the steering groups to the development of future strategies for these centres.<sup>47</sup> On the basis of the criteria adopted, these skill centres would appear to have been generally highly successful.

There are about 15 science and technology parks in Sweden where universities and business are able to meet. This is yet another example of a form of co-operation that draws on international experience.<sup>48</sup> These science parks may be described as environments appropriate to the establishment of new companies, products and forms of co-operation between universities and business. This environment usually houses hived-off companies that have been started by researchers who have wanted to develop and commercialise their own ideas and innovations. Development-oriented companies of differing sizes have located all or part of their activities in the park in order to take advantage of new ideas and to facilitate the recruitment of highly skilled personnel. In Sweden, there are currently about 500 companies in these science and technology parks. In the view of their branch organisation, Swedepark, science and technology parks have made a major contribution to innovation in Swedish industry.<sup>49</sup>

If universities are to make a significant contribution to economic development and technological advance, it is essential that there is a mutual exchange of ideas and personnel between university and industry. Universities have been encouraged by the government to establish a closer co-operation with business without at the same time committing themselves to high-risk projects. Instead researchers are to be given more information and assistance with patents and legal questions. Small and medium-sized companies will also need to be helped in various ways in order to make the best possible use of research and to find suitable forms of R&D co-operation with universities.<sup>50</sup>

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<sup>46</sup> NUTEK 1997 a; 1997 b.

<sup>47</sup> The evaluation team proposed a formal training programme for those in charge of the skill centres. In addition, the latter should meet once a year to exchange experiences. It was also proposed that an annual conference should also be held to discuss scientific and technological developments (NUTEK 1997a, p.5-6)

<sup>48</sup> A further example of co-operation between business and university is provided by the joint project "Technical foresight" run by the Royal Swedish Academy of Engineering Sciences (IVA) and NUTEK. The aim of this project is to assess how research findings can be used to the mutual benefit of both universities and companies. This project which draws on the experiences of similar projects in the USA, Japan and Denmark, indicates that there is considerable interest in adopting a broad approach to the development of technology. The project will submit its report in early 1999.

<sup>49</sup> For further information on Swedepark, see [www.swedepark.se](http://www.swedepark.se). In Sweden there are also seven "technology bridge" foundations that have sought to facilitate work on patents and licences. In addition, they have also tried to convert knowledge and research findings into commercial projects (SOU 1997:37).

<sup>50</sup> SOU 1996:70



## **Industrial Ph.D. programmes**

One concrete method that may be used to strengthen industry's investment in research and new technology is to provide research education directly for those working in industry. This is a relatively new phenomenon in Sweden although Denmark has had a system of industry Ph.D. students since the 1970s. This three-year Danish programme, administered by the Academy of Technical Sciences (ATV), requires that the doctoral student be employed in industry at the same time as he/she follows a doctoral programme at a Danish or foreign university.<sup>51</sup> This programme is first and foremost aimed at private Danish companies that have a direct need to develop their opportunities for technological and economic development. A requirement is that the doctoral project should be part of the company's research and development strategy and have a scientific content. The project is drawn up by the company in co-operation with the university research department. In addition to the Ph.D. courses, the doctoral student will attend courses in management, project control, organisation and co-operation, teach and participate in conferences, write scientific articles etc.

The programme requires that the ATV, on behalf of the Danish state, funds 50 per cent of the doctoral student's salary. Financial assistance is also available to the university for counselling, course expenditure and project costs. The project has to be approved by the ATV, the university and the government department responsible for industrial affairs. At the start of the course, a supervisory group is given responsibility for overseeing the academic studies as well as economic responsibility for the conduct of the course programme. The group consists of a supervisor from the university and from the company. A representative from the ATV selection group is also included in this supervisory group. This person acts as a mentor or contact person with ATV. After the first half year of the course, a final study plan, based on the project application, will have been completed. This plan will provide a detailed description of the contents of the project, timetables for the course plan, travel, the submission of project reports etc. Part of the doctoral programme would also require attendance at a foreign university. Formally the ATV selection group should also approve the plan.

After three years, the Ph.D. student is expected to present a dissertation that will be defended in public. If the project contains information that the company is not willing to publish, the "secrets" are assigned to a special section and remain unpublished. They are not subject to any assessment by the examiners.

About fifty new industrial Ph.D. projects get under way each year. Approximately 450 industrial Ph.D. students have received their training under this programme and almost all of them have subsequently obtained employment in the private sector.

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<sup>51</sup> ATV is more or less comparable with the Swedish Academy of Engineering Sciences. The presentation here is based on their own information material "*Business Research Education, Ph.D. – a co-operative project between the business community and university research*" and "*Business Research Education – an introduction*".

In France, there is another form of industrial doctoral studentship run by the Association de la Recherche Technique (ANRT). About 700 university graduates, mostly from the engineering faculties, receive doctoral studentships. In France, most of the industrial Ph.D. students are also employed by industry during their doctoral studies that cover a period of three years. If the students fail to complete their studies during the allotted time, no further research funding is available. Experience of the French model indicates that the majority of those who receive doctorates remain in industry (ca. 95 %) and that it is both an economical and effective way to increase the number of Ph.D.'s working in industry.

Since 1993, with the Danish and to a certain extent the French prototypes in mind, the Research Council for the Technical Sciences (Teknikvetenskapliga rådet, TFR), has provided funding for industrial Ph.D. studentships in Sweden.<sup>52</sup> Although industrial Ph.D. studentships do not constitute industrial research schools, it is nevertheless a Ph.D. programme that is firmly based in industry. The aim of the programme is to find a cheap way of increasing the number of Ph.D.'s working in industry and to create a bridge between industry and the universities. The recruitment to the programme has been primarily aimed at attracting employees in industry although TFR has sought to market the model in both industry and the universities. The basic idea underlying the project has throughout been that the industrial Ph.D. student should have one foot in industry and the other in the universities.

There are many different types of industrial Ph.D. student. It has generally been the case that a head of research from industry together with a supervisor from university have jointly applied for research funds for a specific industrial Ph.D. project. The Ph.D. student has often been a civil engineer, employed by a large Swedish industrial corporation.<sup>53</sup> Although large companies such as Volvo, Astra, ABB and Ericsson have tended to predominate, small and medium-sized companies such as Lyckeby Starkelse, Regam Medical and Geotronics have also taken part in the programme.

There is no common course plan for industrial Ph.D. students. Instead, under the guidance of the head of research and a university supervisor, each student chooses a number of courses from those available to other Ph.D. students. The principle characteristic of this type of doctoral programme is that the research student conducts his/her studies in a parallel fashion at both the industrial company and university. The industrial Ph.D. student has both an academic supervisor at university and an industrial supervisor at his/her place of work. The same rules apply to industrial Ph.D. students as for other doctoral students studying on traditional Ph.D. programmes. Doctoral studies cover a period of four to six years. Each industrial Ph.D. student has also usually a reference group that includes both his academic and industrial supervisors. The task of the

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<sup>52</sup> The presentation here is based on interviews with the head of administration at the TFR, AnnMari Piloti and Charlotte Hall together with the organisation's Annual Report for 1995/96 (<http://www.tfr.se/tfr/tfr-arkiv.html>, p 13).

<sup>53</sup> A number of doctoral students have also been physics and chemistry graduates.

reference group is to run the industrial Ph.D. project and together with the doctoral student discuss the course plan, his work in the company and the opportunities for practical assignments. It is customary that an industrial Ph.D. student works one day a week in industry in order to keep in touch with "reality".

TFR, a research council concerned with matters of pure science, places high demands on the research projects in which they are financially involved. The "quality control" of industrial Ph.D. students has primarily concentrated on the selection process. If the project does not maintain high standards and is considered not to be entirely relevant, it will be withdrawn at an early stage. The major role of the TFR is to ensure that the project maintains high standards and to provide 50 per cent of the funding. An agreement is drawn up between industry and the university whereby the TFR recommends the parties follow a "model agreement".

Six different universities and a number of companies participate in some form of industrial Ph.D. studentship. The TFR and industry have financed, on an equal basis, almost 50 industrial Ph.D. students. In April 1998, 41 projects were in operation. 11 projects have been completed, more than half of which have resulted in Ph.D.'s while a further 2 have led to licentiate degrees.

In Sweden, the industrial Ph.D. studentship model is still in the process of development. At present, the TFR is seeking to increase interest in this model among small and medium-sized companies as a means of developing and transferring knowledge between university and industry. The first industrial Ph.D. students, who began their doctoral studies in 1993, completed their studies during 1997. No overall evaluation of these projects has yet been carried out. A number of random checks have been made and there are plans to carry out a more systematic appraisal of these projects. Nevertheless the TFR has kept itself relatively well informed about the majority of these projects. In their view, the model of industrial Ph.D. studentships works satisfactorily and has created a unique form of competence. Industrial doctoral students have acquired academic tools in an environment that is able to utilise and draw commercial benefit from skills and knowledge that would otherwise have remained within academic circles. Accordingly it is hoped that the distance between theory and practical application will have been radically shortened. However not all of the new Ph.D. graduates will remain within the companies where they received their training which is naturally considered to be a great loss and a waste of capital by those companies that have helped to finance the programme. However as long as the Ph.D. graduates remain within Sweden, employing their skills and knowledge in either new companies that they have started themselves or in other companies, the industrial Ph.D. studentships can be considered as successful both from the perspective of the financiers of the project and the state. On

the other hand, the loss of a significant proportion of new Ph.D. graduates abroad would naturally be seen as an unforeseen and undesirable effect.<sup>54</sup>

The TFR does not have any views on the research programme itself. The contract is on a one-year renewable basis and if required can be discontinued prematurely. A number of projects have encountered difficulties in getting started. However the projects that are underway and those that have been completed have appeared to work satisfactorily. As is the case with other types of postgraduate education, some doctoral students are able to complete their studies without major problems whereas others require a longer period of time. One indication that the industrial Ph.D. studentship model is considered to be successful is that the Strategic Research Foundation (SSF) has also contributed to the funding of the TFR's industrial Ph.D. studentships. The SSF also participates in the assessment of the programme's quality and relevance. It is the wish of the funding bodies that a larger number of small and medium-sized companies will take part in the project.

## **Research Schools**

Experiments with research schools have been in operation for several years in Sweden. An important underlying motive for the establishment of research schools is the need to provide universities and industry with researchers in areas that are considered to be vital to a society's economic and social development. Research schools are seen as providing creative environments for training researchers and as a meeting place both within the university and in certain cases also for the university and the business community. In the latter case, the aim is to strengthen the competitiveness of Swedish industry and to stimulate economic growth. The American graduate schools such as that at the Massachusetts Institute of Technology (MIT) are one of many sources of inspiration for the Swedish research schools.

The research school experiment was initiated by a Swedish government Act.<sup>55</sup> However it is difficult to provide an exhaustive description of the Swedish research schools since the concept of "research school" is somewhat diffuse. Moreover new educational measures have been subsequently adopted under the heading of "research school".

A distinction has to be made between research schools in Sweden that offer short interdisciplinary courses (from 5 to 20 weeks) and those schools that are built up around a comprehensive research programme. The latter are characterised by better-

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<sup>54</sup> There is an urgent need of an evaluation of the industrial Ph.D. studentship programme. How do the companies that have helped to fund this project assess its value both during the period of study and after its completion? How do the students themselves view the benefits of this type of doctoral programme? At the moment we are unable to answer these questions. New information gathered with the help of interviews and questionnaires is accordingly an urgent priority.

<sup>55</sup> Prop 1992/93:170

organised and more structured research programmes compared to traditional doctoral programmes. They usually have their own administration, an organised curriculum and the capacity to provide research supervision and evaluation of research results. Furthermore, they are usually actively involved in co-operation with the business community and other Swedish and foreign universities. In this way, doctoral students are able to acquire an interdisciplinary approach and the opportunity to create their own invaluable network.<sup>56</sup> Research schools also differ with respect to the extent of their co-operation with industry. Certain research schools have little or no connection with the business community while others have established a well-developed relationship.

Between 1993 and 1997, the FRN (Swedish Council for Planning and co-ordination of Research) together with the Ministry of Education has financed an experimental study comprising about thirty research schools. These research schools may be seen as belonging to the category, shorter "interdisciplinary doctoral courses" with a relatively weak attachment to the business community.<sup>57</sup> According to the results of a questionnaire obtained from 26 out of the 35 research schools supported by the FRN, the primary objective for seven of these research schools has been to raise the quality of the doctoral degree. For a further five, the major priority has been to develop interdisciplinary co-operation, especially between the humanities and social sciences on the one hand and the natural sciences on the other. Only two of the research schools considered that the development of co-operation between the universities and society/business community has been their primary objective while for a further two schools, it has been a secondary objective.<sup>58</sup>

According to an evaluation carried out in the autumn of 1997, the FRN's research schools are a valuable complement to more traditional forms of research education. They have helped to encourage interdisciplinary exchange in the form of courses and research across subject boundaries. Representatives from the business community have been involved in some of these research projects, especially in the field of technology and the natural sciences. However it is still too early to say whether the numbers of completed doctorates and the quality of the theses have increased as a result of the research schools.<sup>59</sup>

The evaluation reports highlighted a number of problems that ought to receive a careful scrutiny when the future of the research schools is under consideration. The *receptive capacity of the institutions*, with respect to supervision and administration, is not able to keep up with the external demands created by additional resources.<sup>60</sup> The question regarding the *long-term viability of the research schools* is naturally associated with the issue of whether or not research schools should be seen as a temporary injection in order to encourage interdisciplinary research or as an attempt to develop a different

<sup>56</sup> Sandström and Huss 1998, p 7 ff.

<sup>57</sup> FRN 1998:4; Carlsson et al 1997 a, p.5.

<sup>58</sup> FRN 1998:4; Carlsson et al 1997 a, p.5; Sandström and Huss 1998, p 9 ff.

<sup>59</sup> Carlsson et al 1997a; FRN 1998:4.

<sup>60</sup> The criteria in the evaluation report are presented here in italics.

type of doctoral programme that will run parallel to the traditional postgraduate system. It is conceivable that the "injection" will encourage the traditional system to take aboard new ideas and move towards an increased degree of interdisciplinary research. If this proved to be the case, the need for this type of research school would disappear in the long run. A number of institutions also point out that the *fixed resources of the research schools* are insufficient to cover the 50 per cent of total expenditure that is a requirement placed on the research schools.<sup>61</sup> The research schools have been highly popular among the Ph.D. students and have also gained the widespread approval of the universities. On the basis of this evaluation, the FRN considers that the research schools should continue to receive financial support for a few more years.

The Strategic Research Foundation (SSF) is one of the principal funding bodies for research schools in Sweden. Together with the Forestry and Agricultural Research Council (SJFR) and the Swedish University of Agricultural Sciences (SLU), the Foundation has funded 27 research schools during the period 1995-2001. When the programme is complete, approximately 800 doctoral students will have been funded in this manner.<sup>62</sup> The SSF research schools may be seen as the type of comprehensive doctoral programme that aims to provide industry with highly qualified personnel without at the same having had a close relationship with industry during the doctoral programme. The research schools have their own governing boards where industry is represented. The only declared objective set by the SSF for the research schools is that between 65 and 80 per cent of the Ph.D. students should be able to find employment within industry on completion of their studies. All of the research programmes financed by the SSF are required to submit annual reports and, at the start of every third year, the research programme is evaluated by the SSF working group and by external, international experts.

In comparison with the FRN financed research schools, a greater number of SSF schools have a declared intention to develop forms of co-operation between universities and society /industry. It is also the most frequently cited primary objective of SSF research schools. Six research schools state that it is their main objective while a similar number place this goal in second, third or fourth position. Three research schools consider that the quality of the Ph.D. degree is their first objective while five others state that this goal is their second or third priority.<sup>63</sup>

According to the evaluation studies, the doctoral students are generally very satisfied with the research programme. However several of the SSF research schools expressed concern about future funding. In comparison with the traditional research degree programmes, research schools would appear to be a relatively expensive form of postgraduate research. As a result, "poor" institutions find it difficult to participate in these programmes. The demand for joint funding also gives rise to a more complicated

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<sup>61</sup> Carlsson et al 1997 a, p 17ff

<sup>62</sup> Sandström and Huss 1998, p.12 ff; *ibid*, appendix, p.33 ff.

<sup>63</sup> Carlsson et al 1997 b. p5

decision-making process where decisions are made at different levels within and between the participating institutions. This is viewed as a management and bureaucracy problem that could endanger the implementation of the research school doctorate programmes.<sup>64</sup>

Finally there is also a potential conflict between the quality of the doctoral dissertations and the demand for a high Ph.D. student turnover. The SSF has emphasised the importance of keeping to the agreed timetable i.e. the Ph.D. dissertation should be completed within four years. It is still too early to evaluate the performance of the SSF schools in relation to their numerous objectives.

If an evaluation of the performance of the research schools is restricted to the assessment provided by those responsible for the research programmes, a number of clear differences emerge between on the one hand, the SSF and FRN funded research schools and traditional Ph.D. programmes on the other. The table below presents a comparison of these assessments of research schools and the traditional doctoral degree programmes in the light of a number of key characteristics.

Table 1: *A comparison between the SSF and FRN funded research schools and traditional Ph.D. programmes.*<sup>65</sup>

Characteristics	Mean value SSF	Mean value FRN
Interdisciplinary co-operation	2.33* (2)	2.36* (1)
Co-operation with potential clients	1.83 (5)	0.86 (10)
Co-operation with foreign universities	0.81 (9)	1.48 (7)
Quality of written work by doctoral students	1.09 (7)	1.38 (8)
Ph.D. student turnover	1.54 (6)	0.96 (9)
Development of new forms of research education	2.24* (3)	1.92 (5)
Correspondence between course and dissertation units	0.67 (11)	1.52 (6)
Interdisciplinary perspective on subject of dissertation	2.20* (4)	2.28* (2)
Proximity to research front	1.00 (8)	2.25* (3)
Extent of network contacts between doctoral students	2.53* (1)	2.04* (4)
Gender distribution	0.76 (10)	0.70 (11)

Commentary: The answers are graded from -3 to +3 and denote the mean values for the SSF and FRN research schools. The value 0 indicates that there is no difference between the research schools and traditional doctoral programmes. The values between 0 and +3 denote that the research schools have to an increasingly greater extent than the traditional doctoral programmes, the specified characteristics, while values between 0 and -3 indicate that research schools have

<sup>64</sup> *ibid*, p 17 ff

<sup>65</sup> Sources: Carlsson et al 1997 a, p.14, Carlsson et al 1997 b, p.12

these specified characteristics to an increasingly lesser extent than the traditional doctoral programmes. The degree of deviation from traditional doctoral programmes is indicated by the figure in parentheses. Significant deviations are denoted by an asterisk.

Interdisciplinary co-operation (> 2.3) is a feature of SSF and FRN supported schools. This is indicated by for example by the creation of networks between doctoral students. Research schools are also shown to have a slight preponderance of males compared with traditional doctoral programmes (>0.7). The quality of the written work produced by doctoral students in the research schools is also considered by those who are responsible for the operation of the research schools to be somewhat higher compared with traditional Ph.D programmes (1.1 – 1.4). Naturally this does not say anything about the quality of future theses in the research schools. The same may also be said regarding the extent to which the research school students complete their theses on time. Proximity to the research front would appear to be rather higher in the FRN schools than in the SSF schools or in the traditional doctoral programmes (2.25) The figures indicate that in one area that is of interest in this context, the different research schools display substantial deviations from each other; SSF research schools develop relationships with potential customers to a greater extent than the FRN research schools and the traditional doctoral programmes (1.8). If this co-operation, particularly with the business community is on a substantial scale, different views may emerge between the various interested parties.<sup>66</sup>

### **Implications for the evaluation of the knowledge transfer programme.**

There are now a couple of decades of international experience in relation to the evaluation of technological and industrial innovation policy. As is the case with all science, distinctions may also be made between different types of evaluation research. For instance a distinction may be made between those that use some type of “control approach” where quantitative methods tend to be used to measure the effects of programmes and policies (usually in the form of cost-benefit analyses) and researchers who consider that individual projects and set objectives are an unsuitable or inadequate unit of analysis.<sup>67</sup> Moreover there are different expectations and understandings with regards to what an evaluation of a programme or policy may provide. Against the background of the evaluation policy research carried out in recent decades, it is perhaps best to adopt a broad perspective when evaluating the effects and relative benefits of a policy. Luke Georghiou argues in favour of what he calls “an adaptive learning approach”. This type of evaluation methodology does not just emphasise the function of essential feedback based on specific measurements but also draws attention to the need

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<sup>66</sup> The assessment by those who are responsible for the implementation of the programmes is a form of self-evaluation which means that an external assessment may give a different picture of the research schools. It should also be emphasised that there are substantial differences between the research schools themselves. This is true of both the FRN and SSF funded schools.

<sup>67</sup> Georghiou 1998, p 47 ff



to provide the key actors with a satisfactory basis for decisions on whether or not a policy should continue to receive support or be discontinued.

Evaluation has become an increasingly important and almost indispensable part of the implementation of projects and policies on a more substantial scale. Few interested parties are satisfied with a simple evaluations based on a few key economic statistics. Comprehensive and well-based evaluations are required in order to at least obtain a sub-optimal use of scarce resources and to legitimise continued funding of a particular project or programme. The days are gone when political or other authoritative decisions were sufficient to justify the implementation of a project or programme.

In order to satisfy the high level of expectations regarding evaluations, primary and secondary as well as short and long-term effects should be taken into account. Internal self-assessment is an inadequate form of evaluation of large projects that involve substantial expenditure. More independent forms of external assessment will also be essential. When evaluation is used as an important part of learning policy processes, where feedback and information give policy makers a well defined basis on which to make decisions regarding the continued funding or discontinuation of a project, the frame of reference in which the evaluation is developed should be clearly stated. Here there is a clear need to ensure that the different interested parties are able to assess the extent to which the evaluation process can be said to be balanced. Where an evaluation is unable to meet all of the requirements and provide answers to all of the questions, it is naturally better to try to evaluate as many sides or dimensions of a policy as possible. This type of mixed assessment is the best that can be achieved in a world where there are no absolute truths.<sup>68</sup>

In order to assess and understand the initiatives taken by the KK Foundation in the fields of knowledge and skills transfer between industry, university and research institutes, a comparison should be made with other attempts to increase the exchange of knowledge between academia and industry.<sup>69</sup> The KK Foundation's programme in relation to industrial research schools is the area that is closest to the initiatives described above in the fields of industrial Ph.D. studentships and research schools. The experience gathered from these activities may therefore be of use when developing and evaluating the new research schools. However the KK Foundation's research schools ought to be viewed in comparison with all other industrial research programmes in Sweden and abroad.

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<sup>68</sup> Fischer 1987

<sup>69</sup> A more detailed presentation of the differences between research schools and their relationship with traditional doctoral programmes is to be found in Carlsson et al (1997 a, 1997 b).

## **The KK Foundation's programme for knowledge diffusion**

### **Origins, aims and objectives**

The Foundation for Knowledge and the Development of Competence, the so-called KK Foundation was founded in 1994 with resources from the Swedish wage-earner fund. The overriding aim of the Foundation was to create conditions that would increase economic growth and improve competitiveness. Its operations are regulated by government decrees passed in June 1994 and January 1997.<sup>70</sup> The following three objectives were laid down in these decrees:

1. To support the exchange of knowledge and competence between business universities and research institutes.
2. To finance research in small and medium-sized universities.
3. To support the development of information technology.

It is envisaged that this programme will *“produce synergy effects via co-operation ”* which will comprise *“generate a sufficient information to bring about a positive change in attitudes”*.

There are five different sub-programmes:

1. Promotion of the use of information technology
2. Diffusion of knowledge and skills between industry, university and research institutes
3. Research in the new universities
4. Reorganisation and renewal of the industrial research system and
5. Information and attitude change

A further two programme units provide support for the above:

6. Planning, monitoring and evaluation and
7. Office administration.

The programme plan lays down the overall long-term objectives together with the annual operational objectives and the activities of each sub-programme.<sup>71</sup> The particular area of activity that is of special interest in this context – the KK Foundation's programme for the diffusion of knowledge – comprises sub-programme 2: *The diffusion of*

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<sup>70</sup> Appendices to government decrees of 23<sup>rd</sup>. June 1994 nr. 63 and 1<sup>st</sup>. January 1997 nr.6, respectively

<sup>71</sup> See for example, KK Foundation, Programme Plan 1997.

*knowledge and skills between industry, university and research institutes* where, according to the KK Foundation's Programme Plan for 1997, the principal goals are:

*An increase in the level of knowledge and skills in industry which will provide universities with know-how and experience that will benefit education, research and research co-operation. As a result, the business community will to an increasing extent be able to benefit from the knowledge available in the universities at the same time as the latter will be increasingly able to provide courses and research that are relevant to the needs of the business community. [and] The establishment and development of research co-operation between universities, research institutes and business in areas that are of strategic importance to Swedish industry*<sup>72</sup>

The programme area may be seen as a bridge between two cultures. The KK Foundation has initiated measures to develop the exchange of knowledge and skills between universities, research institutes and business. This co-operation have been established by means of a dialogue between representatives of the research community and those of small and medium-sized companies. The aim is to improve co-operation between business and the universities. Forms of support are continually devised in order to achieve the goals that have been set for the programme.

As of May 1998, the programme comprises seven different areas:

1. Consortia for the development of skills
2. Company research schools and master's degrees
3. New forms for the exchange of knowledge between small and medium-sized companies and universities
4. Co-operation between the new universities and industry
5. Research into the advancement of knowledge
6. Information, programme planning, and
7. A forestry industry programme.

#### *Consortia for the development of skills*

This area comprises a five year programme designed to create national consortia for the development of skills that will strengthen the exchange of knowledge and skills between universities, research institutes and the business community. A budget of 500 MKr (million kronor) has been allocated for this purpose. The programme has started with a number of preparatory analyses, especially in the area of information technology. An introductory seminar was held on February 9<sup>th</sup> 1998, followed by workshops in Umeå, Gothenburg and Stockholm. Information on the consortia is available on the Knowledge

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<sup>72</sup> Ibid p.27

Network, KNUT, where it is also possible to express views and participate in discussions.

### *Research schools and masters' programmes*

Support for the establishment of company research schools and masters' programmes is yet another method of developing the spread of knowledge and skills between the business community and the universities. Company research schools will, according to the KK model, be developed as a co-operative venture supported by companies, research institutes and the universities. The programme will be inter-disciplinary in its course content. For example, courses will be held in business studies, management, patents and entrepreneurial issues. At least 25 per cent of the course work will be practical work in companies. The course program will be financed in different ways. For example 50 per cent of the wage costs of research students in large companies may be financed at the outset by the KK Foundation. This proportion may be even higher in the case of small companies. Financial support will be given to masters' programmes that provide at least a one year post-graduate training in business-related subjects. Planned expenditure by the KK Foundation in this field amounts to S. Kr. 570 million. However total outlay is likely to be substantially greater since the business community is expected to act as a co-financier of the programme.<sup>73</sup>

### *New forms for the exchange of knowledge between small and medium-sized companies and the universities*

The aim of this programme is *"in different ways and using different methods to try to facilitate contacts between small companies and universities and to develop a better understanding in the universities of the business conditions and requirements of small companies. The overriding objective is that there should be an increase in the number of university graduates in small and medium-sized companies."*<sup>74</sup>

The seven company networks which were started in the autumn of 1996 have concentrated their efforts on establishing contacts with the universities as well as a certain amount of in-house training. In 1998, a number of projects were started up including co-operative ventures with other actors such as Teknikerbrostifteleser<sup>75</sup>. Most of these projects are on a relatively small scale (<1 Mkr). Included among the planned startup networks are:

- A recycling network for used building materials, through, among other things, the use of modern information technology

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<sup>73</sup> This is the most developed and single largest area of expenditure in the KK Foundation's programme. Company research schools will be discussed at greater length in this chapter.

<sup>74</sup> KK Foundation's web site: [www.kks.se/kunskapsutbyte/](http://www.kks.se/kunskapsutbyte/) (1998-03-13)

<sup>75</sup> KK Foundation, Programme Plan 1998, p.28

- A network to provide companies with assistance in their operational and management development, co-operation and network construction, especially in relation to the introduction of innovative procedures.
- A network to create “competent system suppliers” through company development, co-operation and skill development
- A network to increase the mutual exchange of information and knowledge between students, teachers, researchers and small companies through manual designed as a catalyst in the co-operative processes
- A network linking pulverising processes in the food industry
- A network developing co-operation between industrial researchers technical universities and students in Sweden and France

This programme area has been allocated a total budget of 36.8 Mkr for the period up to 2000. A slight increase in this budget has been proposed.<sup>76</sup>

#### *Co-operation between the new universities and industry*

This programme is designed to provide incentives to the new universities to develop their capacity and to find new forms which will enable them to better meet the demands of industry regarding knowledge and skills. This programme which has a budget totalling 120 Mkr is carried out stage-wise in co-operation with the KK Foundation and NUTEK. In the first stage, the universities had to present co-operation proposals before March 6<sup>th</sup> 1998. The universities were also requested to provide an indication of the resources that would be available between 1998 and 2002 for individual industrial Ph.D. and licentiate degree students who are working on problems of concern to industry.

#### *Research into the advancement of knowledge*

The aim of this sub-area is to examine the mechanisms that influence and govern the development of efficient co-operation between university and business. The KK Foundation has accordingly initiated a number of research projects that are designed to study the important role played by the universities in relation to competitiveness, welfare and regional development. A three year research programme has started with the co-operation of the Center for Business and Policy Studies (SNS). The studies undertaken by the KK Foundation in this programme area are co-ordinated with those of other potential financiers, such as the Bank of Sweden's Tercentenary Fund and NUTEK.

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<sup>76</sup> A more detailed description of the various projects is available at the project's home pages

### *Information, programme preparation*

The measures in this area are intended “to contribute to the development of new methods in order that the flow of scientific and research information will be more accurately targeted to both the business community and the general public”.<sup>77</sup> Within the framework of this programme, the KK Foundation finances five positions at the National Science Research Council whose task is to draw attention to the research funded by the Research Council.

### *A forestry industry programme.*

This six year programme was started in 1998 and will comprise three sub-areas: (1) Future utilisation of Sweden's forestry resources, (2) New knowledge in the paper industry, and (3) The forestry industry products of the future. The last-named also includes wood products in the construction industry. “The aim is that the research programme will be of use to the entire forestry industry. With the aid of an interdisciplinary approach which covers social science and the arts as well as science and technology, it is hoped to shed light on issues that are of fundamental importance to the final consumer”.<sup>78</sup> The research will be conducted at the new universities in close association with the established universities, business and the industrial research institutes. The KK Foundation is collaborating on the preparation of this programme with the Department of Industry and Trade.

## **Focus on Company research schools and masters' programmes**

The sub-programme *Company research schools and masters' programmes* is currently the largest programme in volume terms. Its general purpose may be described in the following manner:

*The measures undertaken by the KK Foundation aim to create conditions that will help to draw on the skills and resources of the universities, research institutes and companies for the benefit of the company research schools. The principal objective is to introduce innovations into research education and to adjust it to the needs of business in order that more researchers will be able to work in companies and at the same time ensure that a greater number of those who work in industry will have a research education.*<sup>79</sup>

There are two principal objectives for this sub-area:

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<sup>77</sup> Ibid.

<sup>78</sup> Ibid.

<sup>79</sup> See the KK Foundation's home page located at : <http://www.kks.se/kunskapsbyte/> (1998-03-13)

*An increased number of research educated staff working in industry, i.e. more research graduates will leave university to take up work in industry and more company employees will take part in research education.*

*The competence and resources of the universities, research institutes and companies will be brought together in the company research schools.<sup>80</sup>*

In 1997, the following operational objectives were laid down:

*About five research schools would be started during the year of which a number would be in completely new areas/combination of areas.*

*Research education would be adapted to meet the needs of industry.”<sup>81</sup>*

The work carried out in 1997 in order to reach the stated objectives involved the preparation and appraisal by experts of applications, negotiations and contractual agreements as well as the arrangement of seminars in order to create an interest for company research schools in new areas.

The long term objective (Goal 2000) are that at least 150 persons will begin research education (with the intention of starting a career in industry), the number of staff in industry with research experience (masters, licentiate or doctoral) will increase and that new forms of education would be started, followed up and evaluated.<sup>82</sup>

In the Programme Plan for 1998, a number of additional company research schools were proposed which would act as a complement to the existing schools in terms of organisation and content as well as from a regional point of view. It was also suggested that certain company research schools could possibly be developed into skills development consortia.<sup>83</sup>

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<sup>80</sup> KK Foundation, Programme Plan 1997, p.28

<sup>81</sup> Ibid., p.30

<sup>82</sup> KK Foundation, Programme Plan 1998, p.26

<sup>83</sup> Ibid.

## Applications, selections and approved projects

The invitation to “develop research and education in business-related subjects” was sent out on May 20<sup>th</sup> 1996. The aim was to encourage the universities, research institutes and industry to apply for funds from the KK Foundation. Projects that have an interdisciplinary approach and an IT profile would be given priority. In order to receive funding from the KK Foundation, companies and other interest groups needed to participate in the financing of the projects. Proposals regarding the development of company research schools and the development of masters' programmes would be considered particularly important. A press release from the KK Foundation, 3<sup>rd</sup> June 1996, indicated that there was considerable interest in research education in the field of business.

Proposals for 250 research schools were received and a first selection was made. This was carried out internally by the KK Foundation on the basis of the established criteria (see above). After this initial survey, about 90 applications were considered to be of interest although most of them required revision. Following a dialogue with the authors of the various proposals, 70 applications remained. In light of the criteria laid down for the projects, around twenty were considered acceptable. These were then examined by external assessors, representing business, the universities, public authorities and research council. The final judgements were carried out by three independent judges and by a special working group. As a result of this survey, six company research schools received funding in this first round. Subsequently a research institute was also granted funds for the creation of a company-related research school.

At present, there are eight <sup>84</sup>company research schools that receive support from the KK Foundation. The description of these company research schools presented below is based on their project descriptions.

1. Inst. For Management of Innovation and Technology (IMIT), Chalmers University of Technology and the Stockholm School of Economics: Company Research School within the field of industrial R&D (30.4 Mkr). The Company research school has three principal objectives:

*to develop and establish new forms for co-operation between companies and universities. The aim is therefore to build up a long term, inter-organisational co-operation which is however not based on a formal agreement but rather on a formalised informal network.*

*to renew the organisation of research in the participating universities based on the positive experiences from industrial R&D environments while at the same time establishing research in this field at the smaller universities that have experience of industrial co-operation. Hence the aim is also to try to*

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<sup>84</sup> At present contract discussions are being held with company research schools in Luleå and Lund.



*develop future leaders who will be able to operate on the border between industry and academia.*

*to advance knowledge and to establish a leading centre of competence within project-based R&D which is an area of the greatest importance for Swedish industrial competitiveness.*

*In order to fulfil these objectives, new methods will be developed for the diffusion of knowledge combined with a growth in the number of persons who will act as a link between industry and university. The company research school aims to double the number of active participants and to give a priority to small companies and new universities since they are best reached through the established universities and the major corporations. The company research school will also co-operate with other research schools particularly in relation to courses and educational programmes in the field of project management and project organisation. “<sup>85</sup>*

2. Company research schools in the areas of biotechnology and medical innovations. Karolinska Institut, Centre of Medical Innovations. (38.88 Mkr)

*In the area of biotechnology, genetic research has created new opportunities for biomedical research and biological engineering. New knowledge is the most important factor underlying the radical changes that have taken place in the pharmaceutical industry as processes based on chemical synthesis have been replaced by biotechnology. New combinations of knowledge are required. For this purpose, a new research programme has been developed in the field of biomedical technology – biotechnology – which seeks to provide business with expertise in this area.*

*Molecular and cell biology, biochemistry, genetics and DNA technique are the core areas of this programme as well as R&D organisation and management. Thirty industrial researchers who will run projects in association with industry and Karolinska Institutet (KI) and will be trained within the framework of this project. In different ways, KI will seek to support skills development in small and medium-sized companies while encouraging an increased exchange of knowledge and technology between university and business. The research school will train at least twenty doctoral students. ”<sup>86</sup>*

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<sup>85</sup> See KK Foundation's home page : <http://www.kks.se/projekt/itkunproj/proj5.html> (1998-02-17)

<sup>86</sup> <http://www.kks.se/projekt/itkunproj/proj9.html> (1998-02-17)

3. Company research school within the area of applied IT and industrial software engineering. Linköping University (41.04 Mkr)

*The company research school at Linköping University offers a high quality postgraduate research programme that is attuned to the needs of industry that, in turn, takes account of the university's special IT skills and an efficient organisation that is integrated with an existing research programme and strategic research projects. This supportive business-oriented environment will provide research students with access to substantial supervision and a programme that is adapted to individual needs at master's, licentiate or doctoral level. At the research school, industrial Ph.D students receive a training in software engineering and other related areas of applied engineering.*

*The programme focuses on the engineering aspects of construction, development, production and maintenance of software for industrial processes together with the supportive tools for these processes. Considerable attention is given to the problems that arise in connection with the management of large programme systems and their interaction with both the organisations that are dependent on the development and use of these systems and the computer hardware itself. The areas of application may for example relate to information systems, user interface, real time systems or service production. The research school will train at least twenty Ph.D. students.<sup>87</sup>*

4. Company research school in the field of mining and metallurgy. Luleå University of Technology (11 Mkr)

*The aim of the research school is to provide a high quality postgraduate research programme that is oriented to the needs of industry. The company research school will offer eight industrial Ph.D. places. The most important elements in the research programme are mineral extraction and processing, optimal use of metallurgical products, physical-chemical analytical methods for separation and product adjustment, application of production safety methods and the development of measurement techniques, computer systems and process modelling. The company research school is funded by Boliden AB, the Metallurgical Research Association and Luossavara-Kiirunavaara AB.<sup>88</sup>*

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<sup>87</sup> <http://www.kks.se/projekt/itkunproj/proj10.html> (1998-02-17)

<sup>88</sup> <http://www.kks.se/projekt/itkunproj/proj11.html> (1998-02-17)

5. Company research school in the field of construction and interior environment.<sup>89</sup>  
Department of Building Technology, Construction materials, at the University of Lund (41.3 Mkr)

*Vision: Current qualitative and frequently highly subjective views on questions related to materials and the effect of construction on the health of housing residents should be replaced by more widely accepted quantifiable knowledge.*

*Objective: To use research and education to substantially raise the level of knowledge about the interior environment in the construction industry. In this way it is hoped to avoid the creation of inappropriate interior environments.*

*Target group: All of the principal actors in the construction industry: construction material manufacturers, builders, project designers, clients.*

*Activities: Activities take place in two areas, air quality of interior environments and the sound environment/stability. The activities are:*

- 1. Research into building technology, material technology, chemistry, medicine, acoustics and mechanics.*
- 2. Research education courses for Ph.D. students at company research schools*
- 3. Further education courses for industrial representatives and for students at regional universities*

*The company research school will train at least 20 Ph.D. students.<sup>90</sup>*

6. Company research school at Chalmers University of Technology. Chalmers CORE. (34 Mkr)

*The set-up at the company research school is aimed to produce a new type of Ph.D. who is particularly suited to a leadership role that places considerable demands on competence in relation to change. The substantial element of action research in the doctoral programme will lead to training in qualified reflection, applied systematics and not least interactive interventions (actions) in the participating companies. In contrast to traditional Ph.D.s who are frequently well versed in specific analytical methods and tools, a Ph.D. student*

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<sup>89</sup> Contract discussions are in progress

<sup>90</sup> <http://www.kks.se/projekt/itkunproj/proj12.html> (1998-03-13)

*at the above company research school will instead work from a holistic and action-oriented, methodological perspective.*

*The research programme will thereby adopt an action-research perspective, where relevance criteria are linked to theoretical development. Hence there is no conflict between the development and the application of knowledge. The focus has thereby shifted from problem solving to problem formulation where the solution sets are not given in advance (which is often the case in traditional technical/economic research) but are instead the result of a common reflective process between researcher and practitioner. The Ph.D.'s of the company research school are trained as experts in managing and facilitating those inter-active knowledge-creating processes which provide us with keys to actual developments and an improvement of the state of knowledge. In view of the importance of R&D for enterprise and welfare, this new type of "developer of development work" will become a member of this highly qualified new profession in the knowledge society<sup>91</sup>*

7. Company research school with an orientation towards small and medium-sized companies coordinated by SIK. Institute for Food and Biotechnology (16 Mkr)

*The company research school will train researchers for industry. The objective is that least 80 per cent of those who have completed the Ph.D. course will obtain employment in industry. Throughout the programme which is based on a rapid and highly concentrated course of study built up around specific industry-related modules, the researcher will have continuing close contact with the companies.*

*The objective is to ensure that small and medium-sized companies participate in the research school and the research projects. A further important element is to promote the diffusion of technology into the food industry. Hence the programme will involve knowledge/skills from adjacent areas of technology.<sup>92</sup>*

8. Company research school Trätek AB (10.2 Mkr)

*"Objective: A business-oriented research programme which is co-ordinated with strategic research projects at Trätek and in industry as well as with the existing research programme at Luleå Technical University. During this period , five Ph.D. students will receive training. The programme is geared*

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<sup>91</sup> <http://www.kks.se/projekt/itkunproj/proj2.html> (1998-03-13)

<sup>92</sup> <http://www.kks.se/projekt/itkunproj/proj7.html> (1998-03-13)

*towards recent graduates and for those who have worked for several years and wish to continue their studies at the licentiate or Ph.D. level. The course work is oriented towards environmentally-adapted surface-finishing and gluing as well as the preparatory work together with IT applications for more efficient control of materials and product management.*<sup>93</sup>

### **Current position**

Company research schools that are run with the support of funds from the KK Foundation have been started at different points of time which, in combination with the different procedures followed when starting up company research schools, have given rise to substantial differences in the initial phases of the various company research schools. All of the schools are in the process of establishing themselves and none of them are fully operational. The company research schools that have come furthest have currently recruited half of the planned number of doctoral students. This survey of the company research schools is based on telephone contacts and visits to a number of schools in May 1998 and a study of the records kept at the company research schools. A survey of eight of the company research schools is presented in the table below.

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<sup>93</sup> <http://www.kks.se/projekt/itkunproj/proj16.html> (1998-03-13)

Company Research School	Current position
Fenix (1 and 6 above)	Active board, selection of applicants underway, entry in September 1998. At present, mainly working with four companies
Linköping University (3)	Active board, continuous selection of applicants. 10 graduate students accepted at present (planned total of 20). Working on a stage by stage basis with different types of companies
Karolinska Institutet (2)	Active board, selection of applicants underway, at present (980520) 5 accepted and 8 contracted (planned number of 20). Mainly working at present with four companies. An increase to 12–14 small and medium-sized companies in the biotechnology area is planned.
Trätek AB (8)	Active board, selection of applicants is underway. At present, three of the planned number of five have been accepted.
SIK (7)	Organisation and start-up activities in process, active board, two doctoral students accepted out of a planned total of 11. Recruitment ongoing. Contacts with four companies in the area. (SKI also organises a company research school financed by the Strategic Research Foundation which co-operated with the KK financed company research school.
Luleå University of Technology(4)	starting up
Lunds University (5)	starting up

### *Organisation*

Three main forms of organisation may be seen in relation to the company research schools: (1) A strong relationship to and integration in an established university organisation, normally a department, group of departments or a section of a department (for example the company research school in Linköping). (2) A programme organisation that is more or less independent of the respective university. Here the company research school is usually run on a project basis and the educational courses are purchased from co-operating universities or by a tendering procedure such as Fenix in Gothenburg. (3)

Company research schools are run by an independent industry-related research institute which co-ordinates the activities of one or several university organisations that take on the responsibility for the course programme (for example Trätek and SIK).

The nature of the company relationship also varies between the different company research schools. Here two main forms may be observed. In the first case, there is a connection from the outset with a large or several companies that form a consortium. The other main form is where general information is issued which gradually attracts the interest of both small and large companies. The form that the relationship takes is naturally highly dependent on the orientation of the company research school in question. For instance, the company research school may be primarily interested in a particular industry rather than trying to reach out to the general public.

The Ph.D. students at the company research schools may be either the employees of the main department – a Ph.D. studentship – or of the actual company. It would appear that it is the latter that is usually preferred. Variations frequently arise and in certain cases, the company research schools are willing to accept the idea of flexible solutions.

### *Programme*

The contents and form of the programme will largely depend on the type of organisation and, case by case, on the form of the departmental connection. A close departmental relationship usually implies that the course programme varies little in form or content from an ordinary doctoral course. It is only the company connection that differs.

A less close relationship with a traditional university department would seem to offer an increased opportunity to operate a different type of course programme from that of an ordinary doctoral research education. Here for instance, the course may be characterised by “*continual changes in perspective and paradoxes*”.

Regarding the presentation of doctoral theses, the general understanding would appear to be that these will remain within the existing subject framework, at least over a transitional period. In the long run, it may be possible to create new subjects of an interdisciplinary character.

In this context, it should be borne in mind that research educational programmes may differ substantially between and within universities ( i.e. between different subjects). This means that a certain research education programme may not appear to differ from Ph.D. programmes in general although de facto it does so when comparing the research educational programmes that are actually in place in different universities.

### *Internal evaluation*

The follow-up and evaluation procedures followed by the company research schools in relation to internal evaluation is largely the same as that followed by other Ph.D. programmes (see above), at least to the extent that ordinary research courses are part of the post-graduate programme.

In several cases, the importance of external assessors is raised, particularly due to their formative character. They may naturally be used as part of course development but are nevertheless only a complement to the programme's own internal evaluation.

Internal evaluations are largely carried out in the form of annual follow-up studies (in certain cases, on a term basis) and, in the form of more or less traditional course evaluations related to the particular research courses carried out by the respective departments. It is customary that individual study plans are drawn up for each of the company research school doctoral students. As regards the choice of dissertation subject, certain restrictions on freedom of choice would appear to be in operation, partly to ensure that the research falls within the category of "*appropriate and business-oriented*" and partly as a means of linking up with existing project research and thereby increasing postgraduate student turnover. The latter is also facilitated by the stricter "culture of time" that exists within business and which finds expression in the greater respect for deadlines.

### *Problems*

The occurrence of reported problems is generally low and the majority of them are of the type that is relatively easy to solve or to handle although they may take some time to clear up.

When making company visits, a certain degree of opposition was noted for a number of companies that were reluctant to participate in this type of project to develop skills, particularly in relation to higher education. Arguments that were encountered were for instance "*No funds are available*" and/or "*There is a risk that the company will lose its trained personnel to other companies*" This type of opposition to the development of competence is neither new or unique for company research schools but has been observed in other contexts:

*The participants did not consider that one could generally state that small and medium-sized companies are uninterested in skills development but the following problems were relatively common:*

*Shortage of time: companies have difficulties in releasing key personnel from production*



*Absence of a tradition in certain industries to work systematically with skills development. The head of the company's own lack of formal academic training has given rise to a negative attitude towards universities in the sense that they are not seen to offer anything practical*

*The company's fear that investing in the development of staff skills risks a loss of staff to other companies and new tasks<sup>94</sup>*

Similar arguments also appear in the contacts that company research schools have had with certain companies. Once again the problems will appear to be greatest in relation to small companies. The fear expressed by the latter that they run the risk of losing their skilled personnel would appear to be somewhat less in relation to a company research school doctoral programme than in a traditional research program where the link with the company is considerable weaker, or no longer exists. In other respects, it seems that this kind of attitude among certain companies forms a substantial obstacle to both the activities of the company research schools and to the general development of skills. Changing these attitudes is accordingly a matter of the utmost importance.

Many of the problems that have been reported can be said to be largely administrative. For example, signing contracts is one of the most frequently mentioned problems. Here it is not so much a matter of signing a contract with the funding agency (even though this may in certain cases may be time consuming) but rather reaching an agreement between the company and the educational service provider. Since this area is a relatively new and uncharted territory for both parties, it is hardly surprising that this process would appear to require a lot of time and effort. It should be remembered in this context that two often very different cultures confront each other in this process – the less open culture of the company with its demands for maintaining company secrecy, patents etc and the more open culture of the university with its need for public disclosure of research and other academic activities.

In certain cases, it was stated that problems had arisen in relation to the appointment of the board of the company research schools. A source of conflict in this context was a certain amount of disagreement regarding the principle criteria that should apply to membership of this type of board – traditional subject matter competence or a willingness and preparedness to introduce change. It is also stated in this context that the KK Foundation could facilitate this process by means of clearer instructions and more active support at the appointment stage.

There are also reports of a lack of co-ordination especially when several universities are participating in a company research school. For example, different views have emerged in relation to the distribution of points between the research dissertation and course

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<sup>94</sup> KK Foundation (1998). Summary of discussions in Umeå, Gothenburg and Stockholm in March 1998 concerning the question "How can national consortia participate in the development of skills in small and medium-sized companies? Page 1

work. Although this does not appear to be an insurmountable problem, it can nevertheless point to different perspectives in relation to knowledge that may not be so easily solved.

### *Cultural differences*

Generally speaking, the work that has been carried out may be said to have been characterised by a meeting rather than a clash of different cultures. A number of exceptions have already been noted under the heading “administrative problems” and as principally a matter of different views expressed in relation to reaching agreements and signing contracts. Certain cultural differences have also been interpreted in favour of company research schools, for example the time culture that prevails in the business sector. It is hardly surprising that these cultural interactions have been relatively uneventful during these initial phases. The contacts that have been established arise from a company's positive attitude to higher education and to the university world in general. The same could be said for the committee work of the company research schools since many of the committee members from the business community have previous experience of work in the executive bodies of the universities.

In a few cases however, certain representatives from the universities and higher education have expressed their concerns and a degree of scepticism regarding company research schools, especially in relation to considerations of quality.

## Evaluation proposal

### Introduction

The following discussion will be concerned with a proposal for a national, research-based evaluation of the KK Foundation's programme for the diffusion of knowledge and skills between industry, university and research institute. The programme currently (June 1998) comprises seven different areas, namely, (1) Consortia for the development of skills, (2) Company research schools and master's degrees, (3) New forms for the exchange of knowledge between small and medium-sized companies and the universities, (4) Co-operation between the new universities and industry; (5) Research into the advancement of knowledge; (6) Information, programme planning and (7) A forestry industry programme.

The above areas differ in size, character and development. The first two areas are the largest. Consortia for the development of skills are a new initiative that has a planned expenditure of 500 Mkr over the period to the year 2005. The programme is not yet fully launched although planning and a certain number of preparatory studies are already underway.

Company research schools and masters' programmes are the single largest area of expenditure, with a planned expenditure of 570 Mkr over the period to the year 2000. It is also the best established area. 250 Mkr has already been distributed and a further 200 Mkr has been budgeted for the years 1998 and 1999.

The third area, concerned with new forms for the exchange of knowledge between small and medium-sized companies and the universities is a relatively compact area of expenditure comprising only 36.8 Mkr. The programme has started on a modest scale. The KK Foundation has also provided project assistance varying from 100 000- 1 Mkr in support of the formation of company networks.

The fourth area of the programme is concerned with co-operation between the new universities and medium-sized companies. The emphasis is on the development of new forms of co-operation in order to raise the levels of skills in companies. Within this area, assistance can be given to "Ph.D. students who are working on problems of concern to industry". The Foundation has allocated 60Mkr in this area over the period to 2002. A further 60 Mkr has been allocated to this area by NUTEK. Enquiries about project estimates have already been submitted to those universities that are prospective participants. The programme, however, has not yet commenced.

Areas five and six are markedly different from the rest of the programme. "Research into the advancement of knowledge" is aimed at providing support for the development of research that will help to spread basic knowledge about co-operation between higher education/ research and industry. "Information, programme planning" is concerned with

the dissemination of the information generated by the knowledge exchange programme to industry, government authorities, organisations and mass media. By comparison with the other areas of the programme, expenditure in these areas is modest – a total of 40 Mkr in each area during the period to the year 2000. Work in these areas has started but on a fairly limited scale. Approximately 10 Mkr of the 80 Mkr budgeted has been distributed.

The final part of the programme is concerned with the development and utilisation of scientific knowledge in order to strengthen the competitive position of the Swedish forestry products industry. This area of activity is at an initial stage. Negotiations between the KK Foundation and the government and industry on the content and financing of the programme are still under discussion. None of the 60 Mkr budget has been allocated.

It is obvious, from the above, that the KK Foundation's programme for the exchange of knowledge and skills between business, universities and research institutes is diverse and still in its infancy. Hence it will not be possible to provide at this stage, a detailed plan for an evaluation of the entire programme. Initially, the emphasis in the planned evaluation will be on the second sub- programme, concerned with company research schools and master's programmes. Areas three, four and seven are also very much in accordance with the second part of the programme and should be integrated into the evaluation without too much trouble.

Regarding the first part of the programme, which is a new and major initiative, the results are still far too imprecise for the establishment of firm criteria and the design of an evaluation plan.<sup>95</sup> It is also difficult to identify short-term and measurable results from the projects concerned with co-operation between universities and industry (area five) and into research information (area six). In both cases, it is a matter of assessing effects that cannot be measured until some time has passed.

Regarding areas one, five and six, it is suggested that the evaluation should in this first phase limit itself to the documentation that gradually becomes available in each particular area. Once work in the various areas has become stabilised and results and effects have gradually become discernible, a more detailed plan for the evaluation of these areas of the programme may be worked out and integrated into the evaluation of the programme as a whole.<sup>95</sup>

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<sup>95</sup> At present, there are no clear goals for this part of the programme. *"Well defined goals for the programme will be subsequently drawn up as part of the developmental work with the consortia"* (KK Foundation, Plan of action 1998, p.12)

<sup>95</sup> The level of ambition regarding this extension of the evaluation and the possible consequences that this may have for the staffing and budget of the evaluation project should be discussed prior to any work being carried out on this type of plan.

## **Evaluation of the KK Foundation's company research schools**

The national research-based evaluation of the KK Foundation's initiative on company research schools is not solely concerned with an evaluation of research schools *per se* but also with an evaluation of the effects of what we consider to be a major attempt to shift parts of technical, science and medical research in a more socially relevant direction.<sup>96</sup> However evaluation attention is not focused on the activities of the KK Foundation, although this would naturally be interesting as one of a number of explanations of the programme's possible success. Instead, two problems will be at the heart of the national evaluation. First, the analytical and economic problems associated with the goals, implementation and results of the programme. Secondly, a pedagogical and social problems related to the actual carrying out of the educational programme.

The national evaluation of the research schools is not the only evaluation that will be carried out. The research schools will themselves conduct a continuous follow-up and evaluation of their activities, to develop and to assure the quality of their educational programmes. The aim of these internal evaluations is to ascertain whether the educational programme has fulfilled the goals that the educational providers, co-operating companies and the participants themselves have set. The evaluation should be able to point to what has and has not been satisfactory and to suggest appropriate measures that could be taken to develop and improve the programme. An important aspect of evaluating one's own activities is to examine the views of students, teachers and supervisors in the various companies involved regarding the planning of the courses, their content, teaching methods, literature, supervision, co-operation, research funding, examinations etc. etc.

The KK Foundation will also take on responsibility for following up and evaluating the activities of the research schools. The aim of the KK Foundation's follow-up study is to see whether each project has followed its agreed plan and is proceeding in line with the Foundation's overall goals. The collation of written documentation and annual reports is an important part of this follow-up procedure. Personal visits, conversations with those involved and interviews with key individuals will complement this written material.

The research-based evaluation follows a different approach and will have goals that differ from those of the local evaluation and the KK Foundation's follow-up study. Through its own attention to individual projects, the research-based evaluation will consider the overall programme at the aggregate level in order to study the structural

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<sup>96</sup> This means that the individual research schools will not be analysed separately but jointly and comparatively. Nor will an assessment be made in the national evaluation of the quality of the research carried out in the individual research schools. In addition, detailed knowledge will be required in each individual research area and we assume that individual research schools will themselves take on the responsibility for the quality of their research by using external assessors, benchmarking and peer reviews. (The results of this type of quality assessment will naturally be taken account of in the national evaluation, together with budget analyses, publications, citation indices etc.)

effects on the educational system and industry.<sup>97</sup> An important part of the scientific evaluation will be to try to understand and find explanations for these structural effects. One of the most important tasks of the evaluation will be to provide a continuous feedback to the programme's principal participants – graduate students, educational providers, industrialists and clients. In a longer perspective, our aim is to summarise and evaluate the results of the programme and to draw certain lessons from this experience in the light of future decisions with similar initiatives.

In order to achieve a high degree of credibility and legitimacy for the conclusions drawn from the national evaluation, it will be necessary to validate these results in the context of international experience of similar programmes. The national evaluation will therefore have to be complemented with an international survey. Consequently, a further task for the national evaluation will be to produce material that can be used as a basis for this international appraisal.

In order to ensure that its findings are seen as impartial, it is highly important that the national evaluation is carried out with the utmost scientific integrity. This will be best achieved by an evaluation carried out by independent researchers and an interdisciplinary team of experts drawn from several of the academic areas touched on in the evaluation. The development of a theoretical understanding of higher education and the role of research in the process of social change ought to be an objective *per se*.

### **The goals of the evaluation**

The goals of the national research-based evaluation of the KK Foundation's research school programme are:

- to describe the growth of the company research schools in terms of their preconditions, barriers, opportunities and dynamic features (resources, adaptive capacity, research environment, infrastructure etc.)

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<sup>97</sup> This part of the evaluation will be co-ordinated with a much larger research programme, *The university "in situ" – the role of higher education in the current process of social change*, which was started in 1995 and has engaged researchers from the Universities of Lund and Umeå together with Chalmers Technical University in Gothenburg. This research programme is particularly interested in questions concerned with the relationship between higher education and research on the one hand and Swedish competitiveness, the availability of skills and regional development on the other. This programme is being conducted by a multi-disciplinary research group with an emphasis on social and economic geography, architecture and the history of ideas. Within the framework of this research programme, a team of leading Swedish and foreign academics have carried out a study entitled *Universitetens och högskolornas betydelse för konkurrenskraft, välfärd och regional utveckling* (The significance of higher education for competitiveness, welfare and regional development). This study has also touched on the role of research schools.

- to describe the participating companies in terms of their interests, motives for participation and expectations regarding company schools
- to describe the educational institutions and their interests, motives for participation and expectations regarding company schools
- to describe the recruitment processes and the background, motives and future plans of the students
- to describe the content and structure of the educational programme
- to describe the areas of research, research activities and research relevance of the various company research schools
- to describe the co-operation between different interest groups
- to analyse and evaluate the results of the programme viewed from the perspective of the Ph.D. students, universities and the participating companies
- to survey the academic output of the company research schools and its distribution (publications, participation in conferences, symposia and popular science activities etc.)
- to analyse and evaluate the knowledge generated (originality, innovative capacity, applicability, utility, economic potential etc.)<sup>98</sup>
- to assess the long-term effects of the educational programmes on higher education and research, industry and society (research relevance, supply of skills, competitiveness, regional development and economic growth)
- to develop a theoretical understanding of the role of higher education and research in current social change and thereby to try to understand and explain the importance that a government programme for company research schools may have in this context.

### **The preconditions for a national evaluation**

According to the directives of the KK Foundation, the company research school programme is to be evaluated in relation to the overall goals laid down by the foundation. Among the latter's goals for co-operation between university and industry,

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<sup>98</sup> This is carried out indirectly by means of analyses of assessments made in relation to project applications, reviews of papers and academic articles, participation in conferences, publication indices etc.

emphasis is given to raising the level of knowledge and skill in industry and to the acquisition of knowledge and experience from the business community. Here the stated objective is to increase the capacity of the universities to conduct teaching and research that is relevant to the needs of industry at the same as there is a need to ensure that industry will to an increasing extent will be able to take advantage of the knowledge and research findings of the universities.

Systematic co-operation and mobility of individuals between higher education, industrial research institutes and companies will strengthen contacts between university and industry. This research co-operation will occur within areas that are of strategic importance for Swedish industry. The Foundation seeks to give priority to areas that will have effects that are long-term, generic (producing positive returns on several levels) and exemplary. The programmes that receive support from the KK Foundation are intended to exert a systemic influence and lead to structural changes. The overriding objective in relation to the company research school programme is to renew research education and to adapt it to meet the needs of industry.

The restructuring of the relations between the universities and industry should, according to the KK Foundation, have the following effects:

- increase the mobility of individuals between higher education, research institutes and industry
- increase the volume of research that is directly oriented to meet the needs of industry
- increase the proportion of Ph.D.'s who work in industry and an increase in the proportion of industrial employees who hold Ph.D.'s
- increase the number of research educated staff in industry (an increase in the proportion of Ph.D.'s who work in industry and in the proportion of industrial employees who become Ph.D.'s)
- strengthen industrial research institutes as bridges between research and industry, and
- increase the transfer of technology, knowledge and skills, to small and medium-sized companies.

In addition to these general goals, there are also a number of specific goals for the various projects. For obvious reasons, different research schools may have different goals. However there are also locally determined goals that reappear in several project descriptions. In order to capture the special characteristics of the KK funded company



research schools, we have tried to select those goals that recur most frequently and which tend to differentiate company research schools from other forms of research education.

Without seeking to provide a comprehensive description, the following goals may be mentioned as kind of synthesis of the local goals. From the perspective of the participant, the educational programme should be:

- goal oriented
- rapid (study duration)
- close to industry
- supervisor-intensive
- individually adapted and
- high quality

The educational programme should also be characterised by an increased element of:

- co-operation with industry
- interdisciplinary and problem-based learning
- industry- related course material
- project-based research and development
- direct action research in the participating companies

The educational programme will lead to:

- development of new knowledge and technology that is of relevance to business and society
- transfer of knowledge and technology between higher education and industry
- development of competence, particularly within small and medium-sized companies
- increase in the demand for Ph.D.'s in industry and
- increase in the number of researchers working in industry

The new researchers will (in addition to their basic research skills):

- be trained (and suitable) for leading posts in industry
- have a holistic perspective
- be problem formulators rather than problem solvers
- develop R&D
- have a propensity to change and be disposed to act accordingly
- be able to convert research results into productive activities

In addition to the explicit formulated goals, there are also implicit and underlying unexpressed goals and motives in programmes of this type. Viewed from the perspective of society, the company research school programme is intended to lead to an increase in the investment returns from higher education and research, higher levels of productivity in industry, improvements in competitiveness, the growth of product innovation and new companies, lower levels of unemployment, regional development and a higher level of economic growth in the nation as a whole.<sup>99</sup> Strategic initiatives of this type may be seen from this perspective as an instrument for the achievement of political goals on which there may be some disagreement.<sup>100</sup>

One motive for the participation of higher education and research in company research schools – in addition to all of the officially declared motives – is the need to increase the capacity for research education, to widen its recruitment base and to raise the proportion of externally financed research. Viewed from this perspective, it is not necessarily the case that a publicly funded programme of company research schools is the solution that the universities would consider being the most valuable. If a comparable volume of resources could have been made available to the universities without the commitments that they are obliged to make under the scheme, it is conceivable that this would have been a preferable alternative. The universities and research institutes could then have concentrated on pure research and moreover avoided the risk that their best researchers would leave higher education to take up better-paid positions in industry.

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<sup>99</sup> Cf. with the body of thought that is usually summarised under the heading of human capital, first developed and presented by Theodore Schultz. (see e.g. Schultz, T.W. 1961: *Investment in Human Capital* in Karabel, J & Halsey, A.H. (eds) 1977: *Power and Ideology in Education*. New York: Oxford University Press.

<sup>100</sup> With regards to the use of resources for the purposes of research, there are two possible areas of research policy conflict. At a general level, there is a conflict between investments in technology, natural science and medicine on the one hand and in social science and the humanities on the other. Another type of conflict may emerge between the commitment of resources to pure research as opposed to applied research. At a more general level, there may also be disagreements between the extent to which resources should be devoted to research instead of to other areas of society. Decisions on how resources should be used for the purposes of research often contain implicit views on these research policy issues.

There may however also be good motives for a commitment by higher education to the research schools. For instance, there may be a need to update the education and research conducted in the universities for it to be more in tune with current developments in industry. This would be particularly true of areas such as electronics, computers, telecommunications and medicine where industry has made a heavy investment. Another motive may be to develop the relationship between pure and applied research by means of an increased technological input from industry.

Viewed from the perspective of industry, investments in company research schools should be profitable. This means that industry's need for trained researchers, both quantitatively and qualitatively, will be more easily satisfied under the research school programme than has been previously the case. Closer links to the university will also give companies an increased opportunity to influence the content and pattern of the educational programme in a direction that appears more relevant to the company. In turn this will provide the companies with an opportunity more to rapidly adopt new techniques and knowledge which will give them competitive advantage over other companies.

A further motive for company financial support to research schools is that a close relationship with the universities allows companies to test promising researchers in authentic situations in their own companies, without having to make any commitment. In their subsequent recruitment procedures, they will be able to pick the cherries out of the cake.<sup>101</sup> The company may also be able to solve special research problems at a low cost by allowing the research student to work on them as part of his dissertation.

Naturally there may also be more or less concealed motives for carrying out a research project within the framework of a company research school. Those who are recruited within the university may see an opportunity to gain entry to a company via a company research school and subsequently secure an interesting, secure job and a high salary. For those who are recruited from industry, there may be the attraction of personal development and the possibility of advancing within the company or seeking a new job as a result of the research programme.

## **Evaluation strategy**

A number of considerations have to be taken into account when choosing an evaluation strategy. The starting points for such an analysis are the questions regarding what is to be evaluated, the reason(s) for its evaluation, for whom the evaluation is being carried out and how the results are to be used. In the above we have emphasised that the

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<sup>101</sup> However the opposite may also apply i.e. companies use company research schools as an opportunity for outplacement of unproductive technicians/engineers with problems where entry to a doctoral programme is seen as a much appreciated stimulus, at the same time as society agrees to pay half of their salary.

national evaluation ought to be research-based and directed towards more general knowledge of processes, the results and long-run effects. The aim is to understand what has happened, to find explanations for it and to provide the various interested parties – the students, educational providers, industrialists and clients – with a flow of new knowledge. In a longer perspective, the aim is to summarise the results of the programme so that decision-makers at different levels will be better able to make future decisions regarding similar investments.

The above considerations imply that both an evaluation of the interested parties and an explanatory evaluation model will be required. The former assumes that the interested parties may hold different views regarding the activities that are to be evaluated, dependent on different premises, interests and perspectives. This would suggest that in relation to certain issues there are no absolute objective truths. As an evaluator, it is necessary to describe and explain the subjective standpoints of the different interested parties. What is then considered to be true or false, right or wrong, good or bad is decided by the set of values on which the evaluation is based.<sup>102</sup>

An explanatory evaluation is one of several conceivable evaluation models. Distinctions may be made between different evaluation models with respect to goals, structure, methods, implementation and use of results. Roughly speaking, one may distinguish between product-oriented models, process-oriented models and explanation-oriented models.

The product-oriented models are – as the name suggests- directed towards the analysis of results and the more long-run effects of the activities that are to be evaluated. Normally, the results are compared with the declared goals and with the required investments of time, money and other resources that are essential to the implementation of the programme. The value of the programme is expressed as a ratio between the invested resources and the benefits of the programme. This is what is termed a cost-benefit analysis. The model is based on the rational idea that it is possible, in advance, to formulate clear (measurable) goals, means to reach these goals, and to establish whether or not the goals had been satisfied. Product-oriented evaluations are often carried out by and for higher levels of a command hierarchy. The aim is usually to check on the operations of a programme and to move it in a direction where it will more readily fulfil its goals. This strategy will work well if the goals of the operation are clear and subject to a consensus of view. The strategy is less appropriate when the goals are diffuse or if there is a conflict between the various interested parties in relation to the goals. The lack of process information also makes the strategy less suitable as an instrument that could help to develop and change a programme.

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<sup>102</sup> Compare for example the situation where several people wish to come into a popular restaurant. The doorman may state that the restaurant is full and that they are unable to take any more guests while in the view of those trying to get in, there may be lots of room. What may be considered as right or wrong in this context may be perhaps decided on the basis of the maximum number of people that the restaurant may take, according to the local fire regulations.

Process-oriented models are principally devoted to a study of processes and events. The central idea is that if one can in various ways guarantee that a process will maintain a high quality, the product will also be satisfactory. The processes are often studied informally by means of qualitative methods where the aim is to try to determine the strong and weak sides of a programme. Feedback is constantly provided to those involved in the programme in order that they may move towards the declared goals and the explicitly expressed intentions. Process-oriented models are suitable when a programme is renewed or developed. However the emphasis on qualitative methods, the lack of clear criteria and an overall view make it difficult to establish and explain the results of a particular area of activity.

The primary objective of explanation-oriented evaluation models is to describe the underlying assumptions of a particular programme, to understand the processes involved (what happens) and to explain its results (why it happens the way that it does). This is carried out by systematically relating the observed results to the assumptions and processes of the programme. Interpretation, analysis and evaluation are always made on the basis of an explicitly formulated frame of reference where the studied programme is placed in a larger context. This reference framework satisfies several goals: it is instructive when choosing relevant aspects and methods for data collection, it acts as a basis of interpretation and a source of value judgements in relation to the analysis and evaluation of results. It also provides a point of reference for the assessment of the reliability of the results. The strength of this approach is that it usually provides a good basis on which to make decisions. It also answers questions regarding the satisfaction of goals and at the same time provides valuable feedback to the various interested parties in order that they can develop the processes of the programme.

### **The contents of the evaluation**

A convenient starting point for an explanation-oriented evaluation of the interested parties is to describe the programme that is to be evaluated. This should start with a brief survey of the principle characteristics of the type of research schools that are funded by the KK Foundation. Several questions can be raised here. What can they be expected to achieve? How have they developed? What political considerations have influenced the decision to pursue this initiative? This survey will have to be carried out from both an overall national perspective and from the standpoint of the individual projects. In addition, account will have to be taken of the way in which the project concepts have been developed and reaction to this discussion on the part of the educational providers and the participating companies. In order to identify possible conflicts of goals between the different parties, it is particularly important to examine the negotiation process between those who have put forward the proposals and those who are responsible for the funding.

### *Preconditions*

It is also extremely important to gain an insight at an early stage into the preconditions surrounding the programme, the factors affecting its initial phase and the difficulties and obstacles that have been encountered during its development. This analysis will have, as its starting point, the tasks that the programme has been given according to the project plans. The evaluation should examine the preconditions that affect the capacity of the universities to conduct their operations i.e. premises, equipment, libraries, computers and economic and staff resources. Here we are also concerned with the concept of research environment: the overall scale of the programme (critical mass), organisation, competence, status, research fields, areas of specialisation, tradition, culture, networks etc. Against the background of the overall objectives of the company research schools, it is naturally important to carry out a detailed examination of how the universities, research institutes and industry are expected to co-operate on this project, the number of companies involved, the extent of the collaboration between the various interested parties and the degree to which it has proved successful. In this context, it may be profitable to start out from an analysis of different cultures – the worlds of industry and research – which come together in the company schools. The background of the students, their level of knowledge at the start of the course, motivation, study conditions and future plans are also important components in the analysis of preconditions.

### *Processes*

The processes involved in the programme are also an important subject of analysis. The following central processes in the conduct of an industry-oriented research education will require analysis: management processes; co-operative processes; development of skills; production and dissemination of knowledge.

The management processes are concerned with the organisation and management of the research schools. In more concrete terms, they deal with the planning and distribution of responsibility and work assignments. The recruitment and preparation of staff as well as recruitment measures directed towards potential students are key parts of the management processes. Information, counselling and personnel training together with the overall planning of the content and structure of the programme also belong under this heading.

Teaching and learning processes are essential to the development of individual competence. As an evaluator, one should seek to examine these processes in as detailed a fashion as possible. Student participation, working climate and social relationships are vital aspects in this context. The forms of teaching, working methods and learning strategies are other important areas that will have to be closely examined. As regards the doctoral programme where the student himself will carry out a major part of the work, it will be essential to take a close look at the forms in which thesis

supervision is provided and how the student experiences it. The same applies to assessment and examination procedures.

Co-operation in research groups and networks as well as with clients, service providers and other interested parties are important processes in a research education programme that takes account of the interests and needs of industry. From the point of view of the evaluation, it is important to study how these co-operative functions and the different ways in which it affects the research work. The processes that are required to stimulate the production of knowledge, the development of technology and the dissemination of the research results to industry should also be described. The same also applies to the processes that govern the spread of knowledge in a broader sense where account will have to be taken of research publications, conference participation and a desire to communicate research findings to the wider society.

### *Results*

The purpose of an evaluation that seeks to describe the preconditions and processes involved in the company research school programme is to provide a basis for a better understanding of the results of the programme and to provide explanations for these results. However the results should first of all be examined in relation to the goals that have been set for the programme.

The company research school programme has a number of different goals, formulated at different levels by different interest groups. The goals are both quantitative and qualitative and more or less complex. They are both short and long term and are directed towards different areas in society. It is naturally not easy in such a situation to provide a simple, unambiguous picture of the results of the programme.

A fairly evident result that ought to be the subject of examination is the actual extent to which the programme has actually been implemented. A quantitative analysis of the programme should naturally contain data on the number of applicants, enrolled students and graduates as well as the length of the study period and drop out rate. Data on the number of completed reports, published scientific articles and appearances at national and international conferences as well as the number of Ph.D.'s should also be included in the quantitative analysis.

Although the quantitative analysis is important, an evaluation of the results of the KK Foundation's research school's project will above all be dependent on the quality of the programme, the knowledge and skills acquired by the students and the research results that they have achieved.

In the context of research, quality is primarily defined in relation to the generation of new knowledge and/or new technology. Originality, creativity, innovation and the skilful use

of methodology are the usual criteria for the assessment of research quality. It is in the nature of things that the assessment of the quality of research can only be carried out by experts in their respective areas of research. Indirectly this type of assessment is usually made in conjunction with project applications, reviews of papers and scientific articles and in relation to academic appointments. Direct tests of the quality of research take place in relation to the evaluation of research according to the peer review method and in conjunction with the defence of doctoral theses. As a non-expert evaluator, secondary assessments will also have to be used in the present context.

The usefulness of research results and the criteria of benefit provide us with an external criterion for the assessment of the quality of research. The question to be raised is the following: To what extent have the results of the programme facilitated the spread and use of new technology? Have the results led to patents being taken out on new products and the manufacture of new products? What is the economic significance of the research results? What importance have the results had for regional economic development? What are the economic benefits of the research that has been carried out?

From the perspective of the research student, the research programme will be considered to be successful if it is carried out according to the agreed timetable, meets the high demands for quality, provides relevant knowledge for which there is a demand and leads to interesting and attractive jobs.

Viewed from the perspective of the universities, the research programme will be considered successful if it contributes to high standards of research that attract national and international attention. It is important in this context to emphasise the role of successful research as a means of attracting students, staff and resources. The status of researchers, their personal careers and the demands of industry for their services are also important criteria of success.

Viewed from the perspective of the participating companies, the programme will be considered successful if it strengthens the growth of skills, improves existing processes and products, develops new technology and new products and contributes to the long run profitability of the company. Viewed from the perspective of state and society, the research programme will be deemed successful if it leads to changes in research education, helps produce a new type of company-oriented researcher, increases the number of researchers in industry and leads to the development of new knowledge, technology and products. In the longer term, this should lead to increased competitiveness for the Swedish economy, stronger regional and national economic development, lower unemployment and increased welfare.<sup>103</sup>

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<sup>103</sup> According to our proposal, international experts will carry out the peer review. The success of company research schools will be evaluated in terms of the social criteria and international experience of similar programmes.



## **Interpretation and analysis of results**

The interpretation and analysis of the results must be based on an accurate description of the research programme's preconditions and processes. A first task is to determine the extent to which the research schools fulfil local and national goals. In this way it will be possible to ascertain what is working well and also less well. By then proceeding to examine the results in the light of the project's preconditions and processes, it should be possible to find explanations for what has gone wrong. Finally the processes – what actually happens – can be compared with the prevailing conditions, in order to gain some insights into how the project can be developed and improved. This type of analysis can give rise to a questioning of the project's preconditions i.e. the overall framework and perhaps also its goals.

By relating the three basic components -preconditions, processes and results – to each other, three different types of analysis may be made: an outcome analysis, a process analysis and a resource analysis. Our knowledge of the operation of research schools will be substantially improved by means of this type of analysis. In the following, we will take a closer look at these analytical strategies.

### *Outcome analysis*

In the outcome analyses, the evaluator compares the different results with those preconditions components that are considered on the basis of certain theoretical premises to have a degree of explanatory power. Quantitative results such as the time taken to complete a course of studies and the drop out frequency may be related to the student's educational background, motivation and study conditions. They may be also related to the knowledge and pedagogical skills of the teaching staff and researchers or to the availability of gifted supervisors and interesting research subjects within the participating companies. It is not possible to say a priori which of these explanations will be more credible than others. It is not until the preconditions have been described and the actual results are available that we will be able to find the most plausible explanation in each individual case.

Explanations of outcome in terms of the quality of education may be examined initially with reference to the prevailing conditions that affect the ability of the educational providers to carry out the research education and to the overall availability of resources. In other words, a tight economic framework, insufficient knowledge and experience on the part of the provider of the educational programme, inadequate teaching facilities, difficulties in recruiting good quality teachers/ researchers or a lack of conviction about the idea of company research schools – all of these factors may contribute in one way or other to an explanation of an unsatisfactory quality of education. The explanations may naturally also be found in the participating companies. A shortage of suitable research projects or a shortage of time and commitment on the part of those in

responsible positions in the companies involved may also be important explanatory factors. Once again we cannot know in advance whether this is a reasonable assumption. It is only once empirical data becomes available that we will be able with any degree of certainty to establish the likely explanations for a certain outcome.

The outcome at an individual level – the performance of individual doctoral students – is naturally partly dependent on the quality of the doctoral programme but also on the degree of motivation and ability shown by the students and by their study and working conditions. The participants' motives as regards taking part in a doctoral programme within a company research school and their interest in the courses and research assignments may also be important factors in explaining their study performance.

Regarding the structural and long run effects of the company research schools at a social level, it is difficult a priori to determine how different preconditions may affect a certain outcome. This is related to the difficulties of being able to identify the changes that are attributable to research schools and those that can be associated with general changes in society (for example economic and political conditions, changes in working life, education and labour market policy). Here there is a need for co-operation between a number of experts from different areas – educational sociologists, economists, political scientists, and social geographers – in order to get some help with possible interpretations and explanations.

### *Process analysis*

In the process analysis, a comparison is made between the results of the research programme and the various education-related processes. First and foremost, process variables can be used to explain differences in the quality of education and research. The pace at which students complete their studies and the drop out frequency may also to some extent be explained with the help of process variables.

The strategy in relation to the process analysis is the same as in the case of the analysis of outcomes. The evaluator compares the description of the processes with the observed results. A polarisation technique is often used. This means that an analysis of the process will first try to find everything that is positive, everything that supports the implementation of the research programme in accordance with the stated intentions. At the same time, the polarisation method attempts to locate the weaker aspects of the programme, its problems and barriers to implementation. The stronger and weaker aspects of the programme are then related to the positive and negative effects that appeared in the outcome. The aim is to try to determine why certain aspects of the programme have worked well while others have not done so. This type of analysis provides us with indications of what can be developed and improved as well as of possible solutions. The analysis may also reveal what is problematical and how these problems may be put right or avoided.

The programme's organisation and management, supervision capacity, research group co-operation, collaboration with the private sector, output of knowledge, dissemination of knowledge, assessment criteria and examinations are all examples of process variables that presumably have a greater explanatory power in relation to the quality of company research schools and obtained results.

### *Input analysis*

In the input analysis, the processes involved in the research programme are analysed against the background of the prevailing preconditions. It is above all the available resources, goals and regulatory system that determines and limits the processes. As an evaluator, an analysis can be made of the ways in which resources are utilised, the organisation and implementation of the resource programme as well as the limitations imposed by the various preconditions that govern the programme and determine what is actually possible to achieve. Given these preconditions, the primary purpose of the input analysis is to provide a basis for the optimal use of resource inputs in order to achieve the programme's goals.

The input analysis should lead to proposals that will develop and improve the research programme although it may also reach the conclusion that it is difficult to achieve the programme's goals, given the prevailing preconditions. As a result, the latter may well have to be called into question. Naturally this only applies to those preconditions that can be changed. Normally it is a question of economic resources and the regulatory system governing the programme. In certain cases, the overall goals of the programme may have to be questioned.

### **A graphical illustration of the evaluation model**

The model outlined above for the evaluation of research schools should be viewed as an analytical model – a method of providing structure to the evaluation, a way of thinking – rather than an action plan where one “starts in square one” and proceeds in an orderly fashion towards a specified goal. Working with an evaluation is seldom logical and rational. It is frequently the case that a number of measures are undertaken at the same time or in the “wrong” order. What is of central importance is that one is aware of what one is doing and that there are good reasons for taking a particular line of action rather than any other.

The figure below presents a graphical interpretation of the model that seeks to emphasise certain key aspects and components of the company research school programme. In accordance with the explanatory approach, we have also suggested how

the various components may be related to each other in order to find explanations for the observed outcome.

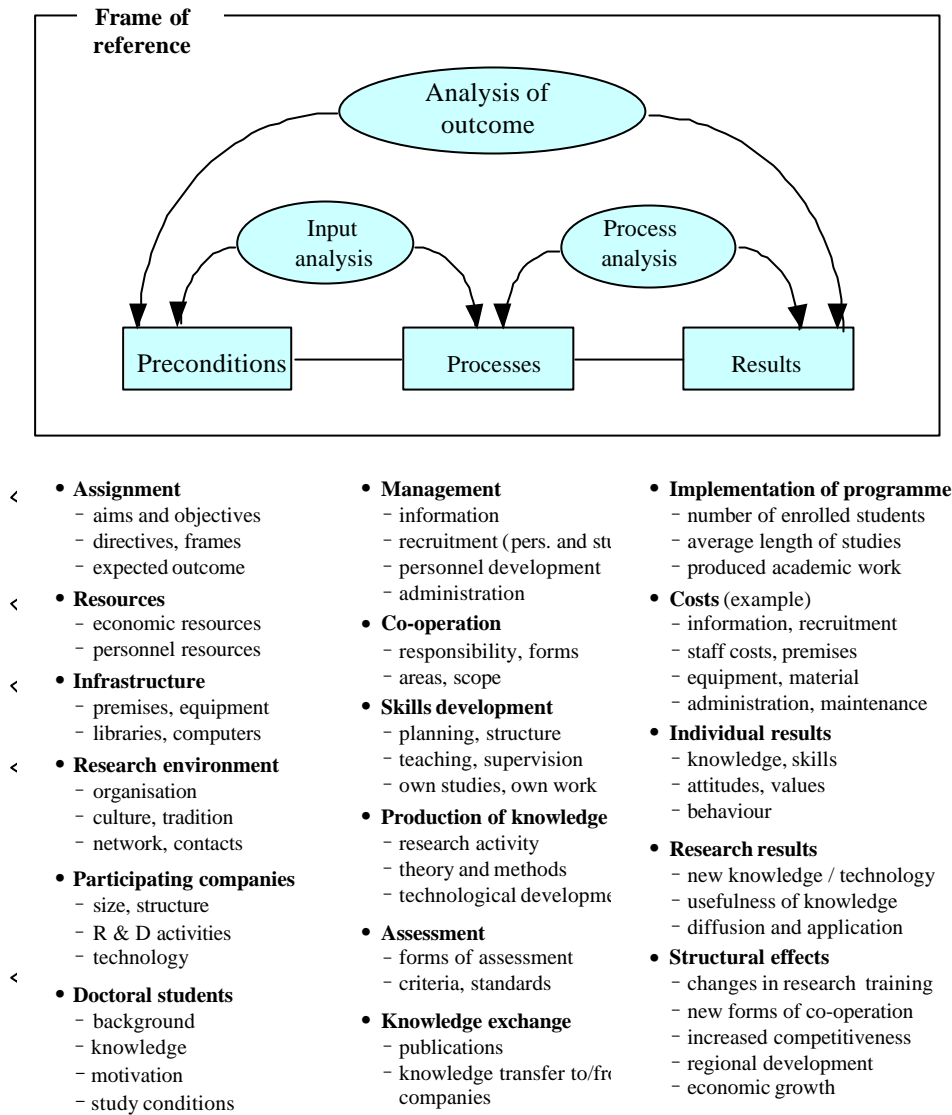


Figure 1. *Evaluation model of KK Foundation's programme for company research schools.*

Since the above model is analytical, it is possible to use it in a flexible manner. The different components in the model may be combined in different ways using different theories and hypotheses regarding the relationships and possible explanations. Accordingly, the model may be applied to a number of smaller studies which can be developed and changed during the evaluation process.

## **The structure and methods of the evaluation study**

The following section contains a rough outline of the structure of the evaluation study. The identification of target groups and methods of data collection have not been carried out in detail. Instead, we have considered which methods and target groups would be appropriate in order to answer the questions posed in the evaluation. A more precise proposal regarding the structure of the evaluation study will be made after the preparatory studies have been completed and following discussions with the expert groups and reference groups. It should also be borne in mind that there is a risk of becoming too committed to a detailed plan at too early a stage. There should always be room for flexibility.

### *Structure*

The evaluation of company research schools should be carried out as an interdisciplinary research project. The emphasis should be firmly placed on political science, economics and pedagogics although skills in business administration, sociology and social geography should also be included in the project. This would perhaps be best achieved within the framework of a research network. It may also be possible to delegate certain limited studies to different experts.

Industry is an important participant in the evaluation process. Hence the representatives of industry ought to be guaranteed a certain amount of influence over the structure and composition of the evaluation. They will need to be provided with a continuous flow of information about the development of the company research schools and the results that they achieve. When interpreting and analysing statistical data, use should be made of the knowledge and experience of industry. However the independence and integrity of researchers regarding methods and results should never be called into question.

In order to ensure that industry is given a voice, a reference group comprising representatives from small and medium-sized companies should be formed. The group should also contain representatives from higher education.

As previously mentioned, there should also be an international group of established and highly respected researchers who are able to analyse and evaluate the Swedish programme for company research schools in an international perspective. The main task confronting the international researchers is to survey and carry out meta analyses of the data from the national evaluation. They ought to also collect their own data in order to evaluate the results of the evaluation. This can be most appropriately carried out by so-called peer review.

## *Methods*

By starting out from the evaluation model for company research schools that we presented earlier, a number of areas can be identified that will provide us with appropriate subjects of analysis. Using these as our point of departure, suitable target groups and methods may be determined.

Knowledge about political intentions, goals, frameworks and directives can be obtained by studying different documents – national statements of policy, project descriptions, protocol, minutes of meetings etc. Studies of documents may, according to requirements, be complemented by interviews with politicians, clients, financiers, board representatives and administrators.

Knowledge about the educational providers- their overall capacity to carry out the research education – may be gained by visits to the different company research schools (observations) and by interviews with certain key individuals – board members, administrators, teachers, research supervisors and participants. Student background, their initial level of knowledge, motivation and future plans may be analysed by means of questionnaire. Sensitive questions about the students' situation and personal views may be enlarged upon in personal interviews.

The processes may be studied directly by means of observations and interviews with the persons involved or affected by the processes. The processes may also be studied indirectly by means of a questionnaire. The primary target groups for the process studies are the administrators, teacher/researcher, supervisor and participating student. The important process information may also be obtained by means of secondary analyses of the evaluations that the educational providers themselves carry out.

The results of the research programme should be described in both quantitative and qualitative terms. The quantitative data should be gathered in a systematic fashion, for example: number of applicants, number of enrolled students, number of drop outs, number of students completing different courses, number of graduates, number of published academic works, number of students who obtain employment in the private sector and costs of different activities.

However, the quality of education and research cannot simply be measured in quantitative terms. Here the evaluation will have to rely on studies of attitudes and value judgements. The material for these studies of attitudes may be gathered in via questionnaires and interviews. Interviews may be preferable if one wishes to try to gain some understanding of the causes of the deficiencies in quality and what may be done about them.

More objective data may also be used to complement the subjective assessment. The capacity of research to attract economic resources, able teachers and students, publication in prestigious academic journals, citation and labour market demands for

doctoral-level researchers are all indications of the quality of a particular research education.

Assessments of the actual results- what the students have actually learned – can hardly be carried out by objective measurements of the quality of knowledge. A survey of the content of a doctoral programme and an analysis of the instruments that have been used for the purposes of assessment and examination provide us with an indirect insight into the knowledge and skills that the students have acquired. Subjective evaluations based on the assessments of teachers, supervisors and the students themselves of what has been learned and its possible application may also yield valuable insights. A more objective measure of what the students have learned may be obtained by an analysis of the way in which they use their knowledge during their practical placements with the host companies.

The most difficult task of all that confronts the evaluator is to obtain reliable information about the long-term structural effects of the company research schools. Nevertheless a comparison of the KK Foundation's programme of company research schools with other types of doctoral education might shed some light on the contribution made by the research schools to the generation of change in postgraduate education in Sweden - in terms of structure, content and working practices. A follow up study of the effects of the withdrawal of external funding would also provide us with evidence. The same applies to forms of co-operation between universities, research institutes and companies.

If the company research school programme does actually influence the growth rate of productivity and competitiveness, market analyses together with an examination of the company's technological and economic development must be employed to try to ascertain how these changes actually take place. The analyses should be based on key figures and complemented by interviews.

In a similar fashion, an analysis of relevant economic statistics and interviews with key people can also be used to study the contribution made by company research schools to regional economic development and economic growth.

Where appropriate, web-based electronic questionnaires may be used to gather quantitative and qualitative data.<sup>104</sup>

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<sup>104</sup> The Umeå Centre for Evaluation Research has developed and tested methods for web-based electronic questionnaires in a number of earlier research projects. These have produced excellent results. The questionnaires are cheap to produce, simple to distribute and easy to return. The response frequency is high and the quality of the answers in the open questions tend to be higher when the respondents answer using a word processing programme rather than replying directly on paper.

### *Sub-studies*

Three basic sub-studies are proposed within the evaluation of the KK Foundation's company research school education and masters' programmes: (1) a *cohort study* where a representative selection of research students are followed through the entire course programme, (2) a *process study* that analyses the educational research processes involved and (3) a *client study* where the conditions and benefits to industry are studied. In addition to these basic studies, a further two analyses ought to be carried out: (4) a *comparative study* where the KK financed programme is compared with a traditional research education and similar programmes that have been carried out by other actors and (5) an *effect study* that examines the long-term effects of the research programme on higher education, research, industry and society.

### **Other evaluations in the knowledge exchange programme**

As we have previously mentioned, the KK Foundation's programme for the diffusion of knowledge and competence between industry, university and research institutes covers many different areas and many different types of programme and – at present – with varying degrees of concreteness. The areas that are closest to the company research school programme and the masters' programme are those that deal with new forms of exchanging knowledge between small and medium-sized companies and the universities (area 3) and co-operation between the new universities and industry (area 4). The goals that the KK Foundation wishes to achieve in these areas are at the same time sub-goals for the research school programme. This means that these areas may be easily integrated with those studies that have been proposed for evaluation of the company research schools. In concrete terms, this means that the collection of written documentation is extended to include those projects that are financed within the framework of these two areas, that the processes are followed in the same way as in the case of the research schools and that certain of the instruments that are used for the assessment of the results and effects of the company research school programme are also adapted and used in the evaluation of these two areas. The major advantage of this type of arrangement is that it will be possible to make comparisons between different measures in order to achieve the same goal. It will also be possible to assess how different measures work in different contexts, to find out which measures are most effective and to examine the interaction effects that may arise.

The KK Foundation's programme for the forest product industry (area 7) has also several similarities with the programme for company research schools. However the difference is that the area is limited to the forest product industry and is only concerned with research that –in broad terms –applies to just that industry. The goals are in other respects fairly similar; to strengthen the forest product industry's market position by means of technological and product development based on academic knowledge, the promotion of co-operation between new and established universities, industrial research



institutes and industry and to increase the number of persons with research education who are actively employed in the forest product industry. It is stated explicitly in the KK Foundation's Activity Plan of Action that "the programme should utilise and develop the experiences from previous initiatives in this area such as the concept of company research schools".<sup>105</sup> The evaluation of the forestry industry programme should therefore be co-ordinated with the evaluation of the company research schools, in the same way as proposed for areas 3 and 4 above.

As regards the other areas – Consortia for the development of skills (area 1); research into the role of higher education for competitiveness, welfare and regional development (area 5); and information, programme planning area 6) – it is difficult at the present time to establish a plan for the coming evaluation. This is partly due to the fact that activities have not yet started, that the formulation of goals in certain areas is not clear and that most of the programmes cannot be expected to have any effect until some time has passed. As far as these areas are concerned, it is proposed that the evaluation in the first phase should simply document activities, describe projects etc. Once the programme has become established, a more detailed plan for the evaluation of these areas will have to be drawn up and integrated with the other evaluation criteria.

### **Successful criteria for the programme area as a whole**

The group of international researchers who have been requested to monitor the preparatory study, prior to the evaluation of the KK Foundation's program for the diffusion of knowledge, emphasise in their report (Etzkowitz et al, 1998) the importance of placing the evaluation in a larger context. Moreover the program should be evaluated as part of an overall strategy for the development of relationships between industry and higher education. In their view, the traditional method for the diffusion of knowledge between university and industry – that is largely based on articles and research reports – is insufficient in today's society. What is needed in addition are concrete meeting places as well as perhaps a closer integration where tacit knowledge is spread in both directions. In order to reach this goal, new forms of co-operation will be required along with a change of attitude in both industry and academia.

In addition to the direct results of the various projects – where the criteria for success may be derived from the projects' goals – the evaluation should also examine the overall objectives and general results such as new forms of co-operation, new methods of transferring knowledge between industry and university, new ways of utilising the knowledge generated by the world of research etc. The evaluation should place greater emphasis on the dynamic effects, albeit unplanned, that may arise. The evaluation should also examine the structural effects that the research program may have on higher education as a whole rather than simply concentrate on the effects on industry.

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<sup>105</sup> KK Foundation: Verksamhetsplan ( Plan of Action ) 1998 (1998-02-17) p.32

In broader terms, it will also be interesting to investigate the reasons for the increased collaboration between universities and certain companies, while others remain relatively uninterested in this type of co-operation. It will also be interesting to examine the needs of these "other companies" and the possibility of providing them with alternative interests. Similarly it would also be interesting to examine how the "normal" doctoral programs are affected by the company research school program. Will they be inspired and adjust to the needs of industry, or will they fall behind and stagnate?

The changes in attitude that can be expected as a result of the KK Foundation's research programme are that companies will become more oriented to academic knowledge, at the same time as universities will develop an increased understanding for industry's own perspective. This may encourage an increase in the flow of information between industry and the world of higher education, and a growing awareness of the business implications of research among academics.

When identifying the indicators and criteria of success, it may be useful to distinguish between (1) changes that occur during the implementation of the program, (2) direct results brought about by the program itself and (3) long-term effects.

Changes that occur during the implementation of the program are inter alia the formation of new contacts, networks and meeting places; new types of research, research education and the development of new methods for the diffusion of knowledge and skills. A number of changes may arise as a result of the program. For instance, the number of PhD's working in industry may increase. The volume of research that has practical applications may also tend to increase. New technologies and products (new patents) will increasingly appear on the market while companies will to a greater extent be able to make use of the new research findings. In the long term, there may be permanent structural changes in industry, higher education and research as well as in society at large.

In the evaluation of the company research schools, a number of more closely defined criteria were presented under the headings "contents of the evaluation" and "structure and methods of the evaluation". These headings are also to a certain extent relevant to areas two, three and seven, which will be integrated into the rest of the evaluation report. As regards the other areas, the choice of indicators and criteria of success will have to wait until these areas of activity have had time to develop and establish a firmer footing. It is important that the identification of these criteria will take place in close conjunction with those who have initiated this activity as well as the various groups affected by and involved in the programme.

## **Timetable and report**

The evaluation project is expected to last for five years, starting in the autumn of 1998. "State of play" reports will be published annually. These reports will describe developments in the various programme areas on the basis of the explanation-oriented model presented above. The annual reports will provide both clients and service provider with feedback, which will allow them to adjust the programme in accordance with its agreed objectives.

At the end of the year 2000, a more detailed half-term report will be presented. This report will contain a complete analysis of the programme's operations at an aggregate level. This half-term report will at the same time provide the international team with their single most important source of information.

Once the international team of evaluators has received the half-term report, they will carry out a series of longer visits to the research schools. Their task is to validate the half-term report and to provide their observations of the programme with an international context.<sup>106</sup> They will submit their external assessment report in May 2002 at the latest. The project group will submit its final report in June 2003.

It should be pointed out that the cohort of research students who are studied within the framework of the evaluation of company research schools ought also to be followed for a period after the completion of their programme. A further period of five years might be reasonable. This should however not lead to any sizeable increase in workload. A series of "point estimates" using questionnaires combined with a brief interview study should be adequate for this purpose.

It might also be interesting to carry out a follow up study of the structural, long-term effects of the entire programme initiative after a further couple of years. This will not however be discussed within the confines of this report.

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<sup>106</sup> The international group will also have other assignments and is assumed to be active during the first part of the evaluation. For more information, see under the heading "The Role of the International Group" on p. 72 in this report

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The KK Industrial Research Schools Evaluation Project

## **A Report on the International Advisory Group (IAG) Meeting in Stockholm**

23-25 April 1998

*Henry Etzkowitz, Luke Georghiou, Luigi Orsenigo*

### **Introduction**

First, we can state that, on the basis of what we have heard and read about the Industrial Research Schools and the proposals for the research-based evaluation it seems to us that the plan is sound. We feel confident about the abilities of the evaluators and have a strong positive impression of the good working relationships that exist between the SNS and the Umea Evaluation Centre, an important prerequisite for a successful project. Indeed, the model established for the evaluation of the research schools, linking academia and industry through the SNS, could usefully be extended to include other KK initiatives, as well.

We also all agreed that the evaluation should be framed within the broader context of the initiatives of the KK Foundation and at a even higher level of generality of the initiatives directed towards the development of industry-university relations. It is clear industry now needs closer relations with universities so that research results are not left behind university walls. Sweden makes a large investment in research relative to its GNP but experiences difficulty in realizing practical gains from these expenditures. Closer cooperation is necessary to enhance the benefits from these research results.

Until recently, industry largely relied on gathering information from academia by reading papers and reports. This has proved insufficient. It is realized that tacit knowledge is needed, as well, to commercialize basic research, to encourage innovations and create new products. Thus, a new format is required for academic-industry cooperation, a meeting place where tacit knowledge can be shared. It will take a variety of organizational and attitudinal changes within industry and academia and the assistance of government and/or quasi-governmental institutions to realize this objective. The KK Industrial Research Schools program, including the evaluation module, is a significant innovative experiment in university-industry cooperation. This report is divided into three sections: (1) comments on the Evaluation Plan itself, (2) international models relevant to the research schools project; and (3) the role of the international advisory group.

## **Evaluation Assumptions and Procedures**

The KK Foundation's research schools project is one of many initiatives directed at encouraging the crossing-over of boundaries between the institutional spheres of academia and industry. Recognizing the interactions among the various projects and disentangling the effects of the research schools will require a broad perspective as well as a close attention to detail on the part of the evaluators. Too close a focus on the research school as a seemingly isolated intervention, as the evaluators are well aware, induce the fallacy of attributing multi-causal effects to a single impetus.

We have been given to understand that the value of the Ph.D. in Sweden is not high. In general there has been an egalitarian orientation, with less emphasis on formal degrees. It is not necessary to have an academic degree for government jobs. Indeed, there are few formal qualification rules and even professors without the Ph.D are not uncommon. Salaries for persons with doctoral degrees are not high and thus it is often not considered profitable for an individual to get a Ph.D. Nor is it traditionally advantageous for companies to hire Ph.D's. Persons with lesser degrees can be trained within the company with the specific knowledge relevant to the firm. Given that such specialized knowledge will be less useful to others, lower salaries can be paid.

### *Goals and Objectives*

There will of course be ex-ante measures based on explicit objectives set forth for the program. The evaluators will also be sensitive to ex-post unintended consequences emerging from the program e.g. increased mobility of research personnel among firms and the emergence of spin-off firms. By this time, some consequences of bringing academia and industry together are fairly predictable. Once collaborations are entered into, industry is likely to move toward a more academic orientation on issues such as sharing information, at some level, among companies as well as with academia. Conversely, as a result of the interaction with industry, academics will likely shift to a more business-like perspective, becoming more sensitive to the commercial implications of research. The next step is to take a more proactive role in capturing financial rewards from such results.

### *Side Effects*

At this stage the main objective of the KK Foundation project lies less in the specific results that will be obtained than in the ability to: generate new relationships and new forms of relationships between industry and universities generate new organizational capabilities within firms to screen, absorb and use knowledge created at universities through the increased availability of highly qualified personnel generate new organizational capabilities within universities to manage the transfer of knowledge to industry, specifically (but not only) through the training of Ph.D's who will eventually work in industry.



As a consequence, the degree of success of the project will have to be assessed to a substantial degree on the basis of the unexpected initiatives that will be generated through the current form of collaboration. Relatedly, the evaluation should emphasize the "dynamic" outcomes of the project, in addition to the direct results. Moreover, specific care should be attributed to the evaluation of the impact of the project within universities and not only within firms.

### *Timing of the evaluation*

One issue which was not discussed in detail during our meeting was that of timing and scheduling of the evaluation activities, although it is partly implicit in the proposal. The proposal for a significant effort to be attached to the pre-conditions for the initiative is extremely important. This is one of the main advantages of real-time evaluation as it allows a) the rationale, objectives and motivations of the stakeholders; and b) the initial state before the intervention; to be documented before they become distorted by hindsight and self-justification.

The next logical phases to examine are the processes of selection for projects, students and their topics. Also any initial changes induced by the initiative in staffing, facilities, organisation etc. The final 'early' activity will be to establish the cohort study. This is likely to comprise the core of the evaluation and needs care and effort. If resources allow, a whole population study could be undertaken, though this should not preclude the possibility of following later cohorts whose composition may differ once the backlog of applicants from partner firms is cleared. Some reward system for the cohort should be considered unless KK makes co-operation of condition of the grant. This would still leave the problem of motivating a comparison cohort from other initiatives and from 'ordinary' doctoral researchers.

After this initial phase evaluation activity is likely to reduce to a more intermittent activity until the cohort nears completion, when effort will need to increase. Ideally there should be a commitment to some sort of follow-up activity to maintain the cohort study beyond the 5 years of the evaluation and hence examine career effects. During the less busy period some time would be available for international comparisons. This information is useful for understanding alternatives, though none will correspond exactly to the Swedish situation, nor will any be directly transferable.

### *Indicators*

Evaluations nowadays are expected to produce indicators. It is important that these are related to the main framework of the evaluation and in aggregate capture the key features of the initiative. Even then it will be difficult to prevent interested parties from taking individual items out of context but there is no solution for this.

In terms of impact/effect indicators it is useful to conceive of these as measuring effects in the Canadian logic chart format, that is: (1) Immediate effects defined as those during

the life of the initiative. Typical items here would be new linkages, changes in the numbers of industrial Ph.D. researchers, changes in the balance of disciplines addressed (or the emergence of new interdisciplinary groupings from those previously with a monodisciplinary background. Negative effects on non-participants (for example transfer of linkages away from other academic centres) are also relevant. (2) Intermediate effects, being what is achieved by the end of the initiative including publication, completed doctorates, patents, use of results of research by companies, follow-up collaborations etc. (3). Ultimate effects, manifested some time after the initiative and including persisting structural and attitudinal changes, benefits to the careers of individuals, benefits to their employers, the role of the doctoral cohort in facilitating future links/technology transfer etc. and ultimately benefits to the Swedish economy and society.

A Caution: There is a danger of expecting too much from a discrete intervention, however worthwhile it is in itself. Thus, the expectation of measurable increase in GNP from the KK research schools might be unrealistic, especially considered apart from other changes with which it is likely to be associated or incorporated within such as the initiation of R&D projects in industry and/or joint academic-industry consortia. Impact on GNP could reasonably be expected from the entire efforts of the various foundations but hardly from one discrete measure that in practice, will be combined with the efforts of others. On the other hand, individual instances of innovations (e.g. a significant patent or instance of technology transfer) achieved in which the graduates of the KK research schools played a role and that could reasonably be attributed to their advanced training should be carefully recorded and analyzed.

#### *Portfolio management: Some additional questions*

How do research schools fit into the overall strategy of the KK Foundation? What is their relationship to other initiatives of the KK or research schools initiated by other foundations. Are they considered as separated projects or integrated into a broader framework? strategically? In practice?

Similarly, how do leaders of the research schools view the project in relation to their other activities and objectives.

Also, how do firms view the project in relation to their R&D strategy and other staff development activities?

To what extent are the research schools based upon pre-existing networks between the firms and the universities? If some are new relationships and some old, how do they compare?

What is the effect of the research school on the regular academic Ph.D. track in the university, if any? Do the universities adopt any of the special features of the research schools program e.g. training in research management, in their regular Ph.D. programs?

What is the effect of the co-financing requirement? Does it limit the research schools to areas of research in which firms already exist? Alternatively, do firms take a long range view, and see the research schools as a means of extending their R&D competencies into new areas. Does the co-financing requirement deter smaller firms from participating? If so, how can this barrier be reduced or eliminated?

A broader issue, of course, is why do some firms or industrial sectors participate in the project and others not?

### *A Cognate Evaluation Model: The Local Attached Evaluator*

The US National Science Foundation's Industry-University Cooperative Research Centers (IUCRC) Program has an evaluation component that might be relevant to an on-going program. Each IUCRC, essentially a club of companies in a specific technology field that pool funds to sponsor research projects at a local university, encouraged by a relatively modest NSF subsidy, has an evaluator attached to each Centre. This person is typically a social scientist or even a humanities professor (e.g. philosopher of science) for the university. Each evaluator regularly fills out a structured questionnaire, conducts interviews with center participants etc. The local evaluator also provides the center director with an independent perspective on center activities in occasional meetings. The IUCRC evaluator is intended as much as a feedback mechanism to the center as an independent source of evaluation. Bi-yearly meetings of the evaluators also provide a mechanism for transfer of ideas among IUCRC's

## **International Comparisons**

A typology of industrial Ph.D. programs can be proposed along the dimensions of scale and scope. Scale can be defined as ranging from programs that target individual students, groups of students and the entire university. Scope can be defined in terms of whether the industrial student pursues their Ph.D. within the regular university program (with accommodations made for their background), a special program designed to meet the needs of industrial students, or an interdisciplinary program designed to meet the needs of industry, irrespective of whether the students derive from industry or not. Of course, there is no "right" or "wrong" approach. Appropriateness depends upon the circumstances in particular countries and regions, available resources and the amenability of academic and industrial cultures to cooperation and change.

### *Brazil*

**Brazil: An Interdisciplinary Ph.D. Program Oriented to SME's: A University Push Model**

The State University of Rio de Janeiro (a teaching university roughly comparable to a Swedish university college in the process of upgrading to university status) recently

established a satellite campus in Nova Friburgo, a small isolated city with declining industry. A regional development strategy was worked out in discussion of academic leaders, government officials (regional and local) and industry groups. The interior region initially wanted an undergraduate engineering program. However, the director of the new campus successfully argued for a graduate education model on the grounds that inserting undergraduate trained engineers into technically limited firms would soon absorb all the graduates they needed, leaving the university without a function. However, if Ph.D.s were produced who could upgrade the capabilities of the local firms, the expansion of these firms would create a larger market for undergraduate engineers. At this point a follow-on undergraduate program could be instituted.

A concept emerged to create a graduate interdisciplinary institution connecting computer science to traditional engineering disciplines. The first step in the plan was a Ph.D. program in computational modeling, including applied math, computer science and with a dissertation requirement to develop a simulation related to one of the other technological areas of the Institute such as materials science, biomaterials, building construction etc. An incubator facility, largely consisting of consulting firms, was also begun, in part, to create links between the new campus and local industry.

### *The United Kingdom*

#### Co-operation Awards in Science and Engineering (CASE).

The largest and longest running scheme is that for Co-operation Awards in Science and Engineering (CASE). This began in 1974/75 and now covers all science, engineering and social science fields. The current 'stock' is around 3,700 students and there were 1,011 new awards in 96/97. Around one-third of graduate students supported by the Engineering and Physical Science Research Council (EPSRC) and the Biotechnology and Biological Sciences Research Council (BBSRC) are under this scheme. Essentially it involves a research topic jointly supervised by an academic body and a partner from industry, commerce or the public sector on a project of interest to the partner. The incentive for the student is that the Research Council stipend is supplemented by a contribution from the partner and also the opportunity to work on a real problem, partly in an industrial environment. For industry the motive is three fold – low cost research (allowing more speculative work to be done), the possibility of developing a useful recruit and, probably most important, building a long term link with the academic supervisor and his/her department.

The academic department receives a contribution from the partner and also benefits from the link (and from attracting better students). There has been no overall evaluation of CASE but parts of the mechanism have been evaluated over the years. It is generally perceived as a success. Lessons emerging which could suggest issues for the study in Sweden include the need for universities to be proactive in building partnerships (industry less frequently initiates them), the need for clarity and an agreement on intellectual property and publication issues, frequent turnover of industrial supervisors

(not necessarily bad but requiring management) and preventing the student from being drawn into 'fire-fighting' when the company is under pressure.

CASE has produced many variants, including 'Industrial CASE' where the studentship is given to a company which then seeks an academic partner, and a scheme to earmark awards for newly-appointed lecturers to help them to develop links with industry. Some of the variants concentrate CASE students in centres, making the scheme resemble more closely the industrial research schools. These include Postgraduate Training Partnerships (where the students are located in 8 research and technology organisations) and Total Technology where four academic centres aim to broaden the skills of young engineers. The Engineering Doctorate is similar. One key difference from the Swedish scheme is that these students are mainly recruited on the open market. The only scheme directed towards those already working in industry is the Integrated Graduate Development Scheme which provides industrially-oriented postgraduate training through short intensive modules related to the needs of companies. There are 45 programmes involving 300 companies but the end point is a Masters not doctoral degree.

*U.S.A.*

#### Rensselaer Polytechnic Institute (RPI): An Individualistic Model

An arrangement with the General Electric Corporation, whose main R&D laboratories in Schenectady, New York are in the same urban conurbation as RPI, located in nearby Troy, New York makes it possible for individuals to pursue advanced degrees at the university, utilizing research that they are working on in the firm. Company employees typically pursue their graduate studies on a part/ time basis. They become members of regular academic research groups, although their participation in the informal side of the research group is necessarily limited since their research is conducted off-site. There are arrangements for safeguarding corporate proprietary research, including publication delays and elision of key details.

The RPI industrial Ph.D. program is based on a long history of interaction with GE. Many RPI professors formerly worked in GE labs. Progression from director of GE Research to President of the University is a not unknown career pathline. Many graduates of RPI find employment in GE. Nevertheless, given the university's other connections and interests, RPI is, of course, much more than an informal academic subsidiary of G.E.

#### The Terman Plan for An Industrial University

During the 1960s, a group of corporations in the pharmaceutical and electronics industries in Northern New Jersey became dissatisfied with the lack of industrial orientation in research training, on the one hand, and lack of opportunities for interaction with academic researchers, locally. At the time, Princeton was viewed as too exclusively oriented to basic research and Rutgers, the State University, as insufficiently developed

as a graduate research institution. Thus, they commissioned a study of the feasibility of founding a new university to meet these needs. A major objective of the initiative was to train Ph.D.'s for industry.

The plan for an industrially oriented, corporation sponsored, university was developed by a committee, chaired by Frederick Terman, the renown Stanford provost who has been credited with the early development of Silicon Valley. However, the proposal for a new university was judged by its corporate sponsors to be prohibitively expensive and the plan was discarded. Nevertheless, corporate dissatisfaction with academia, expressed in this aborted initiative, was one impetus, among several, that later led to a state government sponsored program in the 1980's to develop industrially related research centers at the state's public and private universities. These included a biotechnology center at Rutgers, that raised the research level of the university in this field and provided the neighboring pharmaceutical corporations with an appropriate academic interlocutor.

### **The Role of the International Group**

We see our role as being one of assistance and facilitation not of quality control, though we accept that international inputs always have an added legitimacy. In practice we expect we shall review documents, plans and findings with a view to raising new questions or suggesting additional interpretations. A degree of contact with participants will provide a useful reference point to enable the above task.

We all agreed that the role of the international group will lie in an advisory function to the evaluators, helping them to frame the analysis on a sound conceptual framework, to provide references to other similar experiences as well as to stimulate questions, identify problems, etc.. In this perspective, the objective of publishing a book (or whatever else) provides a good frame and a good incentive for these task. In the same vein, the role of the international group lies also in the dissemination of the results of the evaluation.

The resources of the reference group will have to be systematically exploited to improve both the evaluation and the project. For example, the experience accumulated by some companies (e.g. Astra) in dealing with universities ought to be somehow communicated to the evaluators and to the various participants in the project. Clearly, the members of the international group will have to provide inputs, discussion, information, etc., through all forms of possible communication: e.g. "desk research", reaction to documents, etc., communicated via E-mail, telephone, written reports, etc.

The international group will have to coordinate itself and define quickly the best form of division of labor among us. A generic suggestion, however, is that the group should act and present itself as a single entity as much and as frequently as possible. Our coordination might also imply that in some occasions the three of us (or subgroups of us) could meet independently of the Stockholm official meetings.

In terms of frequency of visits, once a year is the minimum to stay in touch and twice a year probably the maximum that other commitments allow. Of course informal contact by e-mail, telephone etc. can take place with much greater frequency. As a consequence, the international group might meet twice a year to discuss developments with both the evaluators and the reference group, and conducting selected interviews with subjects involved in the project.

In the view of the chair, the complementary, overlapping skills and backgrounds of the three members of the IAG make us an almost ideal, compact team. Given exigencies of scheduling and cost, it seems unnecessary to expand this core group. Of course, additional international participants could be brought in for special events.

As a final word, we would like to say that we are appreciative for the opportunity to participate in what promises to be not only an interesting and productive evaluation but also an opportunity to study emergent issues and trends in academic-industrial relations.