Mika Nieminen
Erkki Kaukonen

UNIVERSITIES AND R&D NETWORKING IN A KNOWLEDGE-BASED ECONOMY

A glance at Finnish developments

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Authors:

Mika Nieminen, M.Soc.Sc., is a researcher in the Science Studies Unit, at the University of Tampere. He has studied higher education policy, S&T policy and university evaluation. Currently he is preparing a doctoral dissertation on the transformation of university research.

Erkki Kaukonen, Ph.D., is senior researcher and head of the Science Studies Unit. His research interests range from international developments in S&T policy to the new dynamics of research communities.

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Even though several people have contributed to this study we, as authors, are naturally responsible for all the possible mistakes (which are hopefully few) and opinions presented in this study.

Tampere, 8 June 2001

Mika Nieminen Erkki Kaukonen

FOREWORD

This study was carried out as a part of the Research Programme on the Finnish Innovation System financed by Sitra, the Finnish National Fund for Research and Development. The national innovation system is defined as the system of organisations and actors whose interaction shapes the innovativeness of the national economy and society. The main goal of the research programme was to identify the future challenges of the Finnish innovation system. In a rapidly changing techno-economic environment, the Finnish innovation system cannot be expected to repeat its recent successes without continuous and effective development effort.

The research programme included 12 research projects that represented several scientific disciplines: sociology, economics, innovation research, psychology, jurisprudence, etc. The cross-disciplinary approach was chosen to gain many different, but complementary, perspectives on the structure and functioning of the innovation system. The close cooperation of scholars from different disciplines was aimed at creating an innovative research environment for the programme. A particular emphasis was laid on understanding the micro-level innovation processes and innovation networks. The research projects went beyond the traditional organisation- and institution-oriented studies of innovation systems in order to better understand the drivers and context of modern innovation processes. In the changed environment, innovation policies cannot be effective without a deep understanding of these processes and their environment. The results of the whole research programme were synthesised in the programme's final report *Transformation of the Finnish innovation system: A network approach* (Gerd Schienstock and Timo Hämäläinen).

Sitra wants to thank all the researchers, policy makers and distinguished foreign experts that contributed to the success of the research programme. The results of the research programme provide plenty of challenges for further research and future innovation policies.

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1 INTRODUCTION

The concepts 'knowledge-based society' and 'knowledge-based economy' have become pervasive in the current literature dealing with societal change and socio-economic development. One cannot miss them in various national and international policy papers or theoretical works by information society 'gurus', economists and students of contemporary society where they appear in multifarious forms. (See e.g. Science and Technology Policy Council of Finland 2000; Schienstock & Kuusi 1999; CCST 1998; Castells 1996; OECD 1996.)

As knowledge (or information) is seen as the key factor in the 'new economy', creating competitiveness, sustainable economic growth and welfare, the science and technology system is expected to carry out key functions in the knowledge-based economy. The OECD, usually playing the tune of international science and technology policy, puts the importance of science and technology as follows:

> *"A country's science system takes on increased importance in a knowledge-based economy. Public research laboratories and institutions of higher education are at the core of the science system, which more broadly includes government science ministries and research councils, certain enterprises and other private bodies, and supporting infrastructure. In the knowledge-based economy, the science system contributes to the key functions of: i) knowledge production — developing and providing new knowledge; ii) knowledge transmission — educating and developing human resources; and iii) knowledge transfer — disseminating knowledge and providing inputs to problem solving."* (OECD 1996, 21.)

This doctrine together with a new understanding of the nature and mechanisms of innovation has created policy challenges for governments both on national and international levels. Governments' actions in supporting technological development and human resource training have been seen as the fundamental basis for the knowledge-based economy to work. In addition, government subsidies and loans for R&D, training and exports are considered critical in positioning firms in the global competition. (E.g. Castells 1996, 105.)

From the perspective of a knowledge-based economy, governments have currently two basic roles in developing science and technology. First, they provide financial support for research, and second, improve the interaction between science and society. These aspects involve the basic problems the governments have to tackle in their policies: providing sufficient funding for long-term research and researcher training; finding a balance between core and external funding in order to stimulate interaction between academia and society; finding a balance between mission-oriented and non-oriented financing for curiosity-driven research; creating measures to stimulate cooperation; removing barriers to cooperation; and facilitating the mobility of scientists and engineers. (OECD 1998, 78–79.)

Not only governments are facing challenges in science and technology (S&T), but also firms are formulating new strategies that are based on "simultaneous co-operative and competitive relationships at multiple levels of the business environment" (Carayannis & Alexander 1999, 198). Especially in high-technology and knowledge-intensive industries, the way to compete differs substantially from traditional modes of competition. Firms create strategic alliances and contract more often to obtain university research in order to widen their knowledge base. One reason for new kinds of government-university-industry strategic partnerships is that firms can improve the exploitation of their internal knowledge by using complementary external sources of knowledge (other companies, universities, governmental research institutes). (Ibid., 203.) It seems that

> *"openness is vital for the efficient use of costly research resources in creating reliable knowledge. Open access distributes knowledge widely and rapidly: facilitates independent replications of findings; promotes swift generalization of results; avoids excessive duplication of research; increases the probability of creating useful new products, processes, and ideas arising from novel and unanticipated combinations because new knowledge is available to many researchers; thus raises the social value of knowledge by lowering the chance that it will reside with persons and groups who lack the resources and ability to exploit it* "(Foray 1997, 66).

The changing research environment sets challenges for the traditional university organization as well. Traditional administrational and decision-making procedures, ways of organizing faculties and departments, and the ways of linking teaching, research and service functions are under pressure to give way to more flexible structures in an environment emphasizing the economic and societal relevance of research and training. However, not only the idea that the universities should yield applicable knowledge, but also the increasing complexity of scientific problems and research, as well as the development of new multi- or cross-disciplinary research areas, have posed challenges for university-based knowledge production. (See e.g. Geuna 1999; Slaughter & Leslie 1997; Ziman 1994.)

From these starting points university-industry cooperation and transformation of science and technology have become a 'heated' issue in science, technology and innovation studies. The 'network perspective' is most prominently presented in the literature dealing with innovation systems (e.g. Edqvist 1997; Nelson 1993), innovation networks (e.g. Miettinen et al. 1999; Camagni 1991) and institutional integration of S&T (e.g. Etzkowitz & Leydesdorff 1997). The 'transformation perspective' has been prevailing in the debate on new forms of knowledge production (e.g. Hellström & Jacob 2000; Ziman 1996; Gibbons et al. 1994). In addition a growing number of empirical papers and reports has focused on networks in knowledge production and utilization (e.g. Malo & Geuna 1999; Nedeva 1999; Schibany et al. 1999; Zieminski & Warda 1999; Laudel & Gläser 1998; Howells et al. 1998; Jasinski 1997).

In general, innovation studies have mainly focused on the diffusion, management and utilization of knowledge from the perspective of the business enterprise sector. In spite of the fact that new knowledge is considered to be a central prerequisite for technological and economic development, changes in the conditions for and organization of knowledge production and the changing role of knowledge producers in an innovation system have been studied much less. There has been little domestic research on these issues so far and no systematic studies focusing on R&D cooperation among universities, firms and governmental research institutes.

The basic assumption of this study has been that it is important to know the mechanisms, conditions and actual developments in research and knowledge production besides those related to knowledge transfer and utilization of new knowledge and, hence, to study the wider connection between research and innovation, as mediated by R&D cooperation. The aim of the study was, therefore, to analyze the development of research especially from the university perspective, describe the development of interaction and research cooperation among universities, governmental research institutes and industrial R&D activities, and to clarify factors which affect research cooperation and knowledge transfer in university research.

The study is divided into three sections. The first focuses on theoretical questions and outlines the framework for the study. Questions addressed in this section are, for instance, how useful publicly funded research is, in what ways the research system is changing, and what kinds of perspectives can be assumed when science-society linkages are studied? In addition, the section introduces the data and methods applied in the study. The following section begins with a short description and analysis of changing S&T policy priorities on national and university levels. Thereafter, themes related to science-society linkage are discussed by using three kinds of empirical data. The first data set consists of R&D funding statistics used to analyze the diversity of funding sources among disciplines and universities. The statistics not only show the relative success of various disciplines and universities in the 'funding game', but also reflect university research ties to different actors like ministries and companies. The second kind of data consists of interviews with leaders and senior researchers in university units and departments that are active in non-academic research cooperation ('non-academic' does not refer to the content of research activities but to research partners which are acting outside universities, like ministries, companies and civil society organizations). What is the role of public finance in creating research cooperation, how is research cooperation is constructed, what kinds of experiences have the interviewees in cooperation? The third type of empirical evidence comes from a survey conducted among companies in three different regions in Finland. In this part the discussion focuses on the characteristics of companies that have university cooperation as well as their experiences in the cooperation. The third section of the study sums up the results of the empirical analysis and discusses the development of university research as well as puts forward potential S&T policy-relevant questions on the development of science-society linkages.

2 RESEARCH: TRANSFORMATION, SOCIETAL SIGNIFICANCE AND LINKAGES

Knowledge production in transition

During the recent decades rapid societal change – the growing importance of information and knowledge, rapid technological development and globalization of the world economy – has both directly and indirectly affected conditions for the functioning of knowledge-production systems. Universities, enterprises and government laboratories have all faced new challenges, possibilities, and constraints in knowledge production. Interaction between scientific development and societal demands has produced a functional change within the R&D system.

These transitions have produced a whole new set of organizational dynamics and governmental policies. Increasing international economic competition and the rapid development of new technologies have, for instance, provoked ideas that the basic research function of the universities is insufficient and universities have to yield also directly applicable knowledge, which can lead to commercial innovations. Concurrently, the increasing complexity of scientific problems and research as well as the development of new multi- or cross-disciplinary research areas has highlighted the necessity of crossing old scientific and institutional boundaries. As a consequence, the traditional university culture and structure have been seen even more as obstacles than as supporting elements in knowledge production. Governments have reacted, in turn, by initiating new policy programs aimed at improving the efficiency and effectiveness of university knowledge production. Among other things, monetary incentives, quasi-market mechanisms and a shift of emphasis from core funding to competitive funding sources have played crucial roles. Governments have also supported the establishment of science parks and co-operative R&D centers, and initiated various programs in order to promote knowledge transfer from academia to industrial and commercial use. In this process industrial policy has been increasingly linked to science and technology policy. (E.g. Geuna 1999; OECD 1998a; OECD 1998b; Slaughter & Leslie 1997; Ziman 1994; Van Dierdonck et al. 1991.)

In recent S&T discussions particularly two perspectives on this transition have been visible. The first has emphasized an increasing institutional integration in the S&T system. This approach is reflected in the concept of 'Triple Helix' of university-industry-government relations (Etzkowitz & Leydesdorff 1997) as well as in the rapidly growing literature on innovation systems. The other perspective has emphasized changes in the priorities of research; it is commonly maintained that a shift of emphasis is taking place from the disciplinary context of knowledge production to an application-oriented and entrepreneurial context of R&D (Gibbons et al. 1994).

Traditionally the three main sectors of knowledge production – universities, government research institutes and industrial R&D – have operated at arms length from each other. However, according to Etzkowitz and Leydesdorff (1997), there is now taking place an increasing functional and institutional integration of the three sectors: a 'Triple Helix' -development. Increasing economic constraints have led to a situation in which universities are trying to capitalize on their research and education functions, setting up direct contacts with markets and industry. The new entrepreneurial activities have included, for instance, new technology and knowledge transfer functions, technology centers, research liaison offices, university-industry joint research projects as well as new services. Concurrently, international competition and a faster phase of technological development have made enterprises more receptive to external sources of innovation. They are now actively seeking out new knowledge and externalization of former in-house research activities. As a consequence research groups within firms have become elements of joint research ventures, bringing them into contact with government laboratories and university-based research groups. The process transforms each sector's role as they assume each other's traditionally differentiated functions. As a result the relatively stable boundaries between various disciplines and institutional actors as well as between basic research, applied research and development are loosing much of their effects and visibility. The three helices of university, government and the enterprise sector are intertwined with each other in a process like a 'triple helix'.

The 'Triple Helix' view of the development of the S&T system comes rather close to studies in which national systems of innovation are in focus. These studies can be seen as resting on the premise that the determinants of success for enterprises, and for national economies as a whole, are increasingly reliant upon effectiveness in gathering and utilizing knowledge in knowledge-based economies. Since no actor can be totally self-sufficient in knowledge production and utilization, strategic knowledge and information are developed and shared in networks that, in turn, determine the future prospects of firms and national economies. (OECD 1996.) These networks, in turn, may form entities that have been called national systems of innovation.

Even though the concept of national systems of innovation is widely utilized, there is no single accepted definition of it (for different definitions see e.g. OECD 1997). This seems to be simply because of the heterogeneous nature of innovations as well as of activities and actors that can be related to innovation. As a consequence, the definitions are usually rather broad, albeit the focus is usually on technological innovations. For instance, Freeman (1987) has defined a national system of innovation as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies".

Due to the broad scope of the concept it can be considered as rather problematic. We may, for instance, consider 'system' in this concept. In general, a system is any structured or patterned relationship among a number of elements, where this system forms a whole or unity. A system is distinguishable from its environment and it has more or less visible boundaries and it exchanges inputs and outputs with its environment. In systems theory it is also usually assumed that systems tend towards an equilibrium state or homeostasis. Without going any further into systems theory, these definitions show some problems in the concept of 'national systems of innovation'. Where are, for instance, the boundaries of such a system? If the system includes, besides knowledge producers and users, infrastructures like different policies and policy actors, and if such entities like markets can be considered rather as endogenous than as exogenous factors in an innovation 'system', it does become rather difficult to define any boundaries in relation to other subsystems – at least if we talk in functional terms. As Nelson and Rosenberg (1993, 4–5) note, if we accept a broad definition of innovation, it is extremely difficult to determine what should be included in the innovation system, and what could be left out. In addition, the actors and processes which support innovations in one field, may not be in place in another field. For instance, pharmaceuticals and telecommunications may have very few common institutions that support innovations (cf. ibid.). In this sense we could rather speak about systems than a system – a national system of innovation can be seen consisting of several inter-related sub-systems. More radically we could even question the sensibility of the use of the term system – at least in its strongest sense – since it is difficult to articulate those dimensions and qualities which make the national system of innovation as a system. Should we perhaps instead refer to 'networks of innovation'?

Perhaps the most debated analysis of the changing nature of knowledge production has been put forward by Gibbons et al. in their book *The New Production of Knowledge* (1994). Their main thesis is that a radical shift in scientific knowledge production has taken place from the traditional disciplinary-based knowledge production to a more application-oriented one. They call this new mode of knowledge production 'Mode 2' and the traditional one 'Mode 1'. The most important feature that seems to distinguish Mode 2 from previous arrangements for consultancy and commissioned research is its negotiated character. Knowledge is produced through a process of continuous negotiation of needs, interests and specifications of all the involved actors.(Jacob 1997, 38.)

The preconditions for the evolvement of a new mode of knowledge production are laid down in a parallel expansion of knowledge producers on the supply side and the expansion of the requirement for specialized knowledge on the demand side. Even though the driving force behind this accelerated supply of and demand for marketable knowledge lies in the intensification of international competition in business and industry, it is also maintained that much of the impulse for a shift to Mode 2 has been endogenous to the practice of Mode 1. Since in many cases a precondition for extramural funding has been a defined problem context and the problem solving requires networking with other industrial, governmental or university research units, the hold of Mode 1 knowledge production imperatives has been weakened and the distinctions between pure and applied science as well as between curiosity-oriented and mission-oriented research have been softened. (Gibbons et al. 1994.)

The problem with such descriptive polarities is usually that they create an image of strong discontinuity. The development seems to break down radically and the novel organization is emerging 'from nowhere'. Thus Gibbons et al. emphasize that the aim of introducing the two modes is essentially heuristic and the change is not a simultaneous process in all parts of the research system. Some disciplines have already, more or less, assumed the new mode of knowledge production while the other ones may still operate in the traditional disciplinary context. Mode 2 knowledge production is moving beyond the traditional disciplinary context, while much of academic science functions according to Mode 1 principles. As a matter of fact, Mode 2 science is in constant interaction with Mode 1 science, since researchers in Mode 2 knowledge production have been educated in the context of traditional academic science (Mode 1).

Mode 1	**Mode 2**
primarily cognitive context	context of application
curiosity-oriented in a non-specific context	problem-oriented in a specific and localized context
mono- or multidisciplinary	trans-disciplinary
homogenous and hierarchically organized	non-hierarchical, heterogeneously organized and close interaction of many actors
stable forms of organization	transient forms of organization
accountable to peer groups	socially accountable and reflexive
internal scientific quality control	wider set of socially determined criteria for quality control
restricted difffusion of knowledge	knowledge production diffused throughout society

Figure 1. A summary of the attributes of Mode 1 and Mode 2 knowledge production, according to Gibbons et al. 1994, 1—16.

If something can be summarized from the above presented views, it would be perhaps that most of the observers seem to be assured that the globalizing economy with its new knowledge claims is changing the nature of knowledge from a 'public good' to a 'market commodity'. This seems to be especially true in the knowledge areas and disciplines that are defined as having 'strategic value' in the economic development. Laurie Anne Whitt (1998, 33), for instance, claims provocatively that:

> *"The ideology of the market, and the omnipresence of market forces, have left an indelible mark on the Western conception of knowledge. Aided and abetted by the Western legal system, and most strikingly by the rise of intellectual property law, knowledge has undergone a steady process of commodification. This is particularly true of knowledge produced in the microworld 'factories' of Western biotechnosciences, which have become crucial outposts in the establishment of an international intellectual property rights regime. As capitalism moves from an industrial to a global information economy, it continues to regenerate itself."*

In other words, it seems that the social meaning and function of science is changing. Even though it can be maintained that the boundary between science as public knowledge and proprietary knowledge has never been clear, it seems that research which is conducted in the academic institutions out of 'curiosity' is more and more seen as an 'intellectual property' the ownership of which needs to be protected. At the same time, changes in the law are taking place and many universities are laying down rules to deal with legal and financial aspects of intellectual property rights. (Cf. Etzkowitz 1989.)

This development is not unproblematic. For instance, John Ziman (1996) has postulated that Mode 2 represents a decisive break in relation to the classical Mertonian norms and ethos of science. One of his claims is that as the research teams in Mode 2 operate extensively in the context of application and in most cases with problems that ultimately have a commercial basis, this indicates that Mode 2 knowledge is proprietary by nature and under commercial property rights. Thus, it is obvious that research results which a (traditional) academic scientist would have published as soon as possible are now defined as intellectual property, and may be kept secret for longer or shorter times for commercial purposes. The close connection to commercial applications may undermine the publicity of research results.

Ziman states also that Mode 2 may not favor metaphysical universalism. By this he means that Mode 2 is organized around the solution of problems rather than directed towards the production of knowledge as such. It follows that the knowledge produced is intrinsically local rather than universal. What counts as good science may be a technical skill at problem solving, rather than advancement of our understanding. This implies ultimately that the former pursuit of knowledge as such is replaced by an instrumental rationale in which problems are posed and attacked in a technical fashion without the reduction of observed phenomena to more fundamental principles.

Likewise the norm of disinterestedness may be under strain in Mode 2. According to Ziman, the erosion of disinterestedness is connected to the funding circumstances and employment possibilities: Mode 2 research teams cannot provide stable employment for most of their members, as teams are constantly reconfigured for new problem solving contexts and funding is unstable. Mode 2 science is funded by a complex of governmental bodies, large public institutions and private corporations. The interests of funding organs may undermine independent problem selection and affect the orientation of research. This 'impersonalization' of research work is connected to the general demand for efficiency. The general answer of Mode 2 science to this request is to try to eliminate waste by ensuring that research projects are well-designed and directed towards well-posed problems. Therefore, Ziman concludes, as traditional academic science offers results on innumerable different problems, being a quite 'wasteful' process, Mode 2 tries to eliminate this 'waste' by pushing research in desired directions by strongly favoring research on particular problems and limiting the range of variation of research projects on a wider social basis.

Universities increasing collaboration with industry and industrial funding has indeed provoked wide debate on the possible benefits and costs of such arrangements. The policy debate around unintended negative consequences started during the early 1980s and the issues raised by several observers (like Ziman above) have continued to have salience. It seems, however, that there are relatively few empirical studies that have addressed the costs of cooperative research from the researcher's perspective. The evidence from these studies is also somewhat contradictory and does not cover all the fields of science. (Behrens & Gray 2001.) For instance, Blumenthal et al. (1996) have reported that in the life sciences, faculty (n=2 167) who received research support from industry reported more publications than faculty without industry support. However, the faculty who received over two-thirds of their support from industry reported fewer publications than faculty with low or moderate support from industry. On the other hand, Allen and Norling (1990; according to Behrens & Gray 2001) conducted a survey of 400 faculties and came to the conclusion that most faculty involved in commercial activities resembled faculty not involved in such activities in terms of publishing and generating pure knowledge. The question of the unintended consequences of increasing industrial collaboration seems, thus, to be still very much unanswered and further empirical studies would be welcomed to clarify systematically these questions.

The economic significance of public science

The idea that knowledge has economic significance is not a new one. Adam Smith, for instance, wrote already in 1776 about the economic significance of human capital. Schumpeter, however, has usually been mentioned as the first theorist who saw the significance of innovations for industrial renewal. In the early 1900's he wrote about the emergence, development and decline of industries with emphasis on the role of innovations in industrial renewal. However, he did not see the role of science as decisive but rather a special kind of entrepreneurs, 'innovators', who were at the forefront of industrial renewal. (Palmberg et al. 1999, 5–8.)

Even though there already were good examples of the potential of systematic scientific research in the beginning of the 1900s, for instance, in the chemical industry, systematic political attempts to utilize science for industrial or other societal purposes were still relatively rare. It was the experience of World War II that raised new ideas about the role of science in civilian and industrial use. Especially in the U.S. scientists were recruited to support military efforts. These new affiliations together with the positive wartime experiences raised new ideas both about the role of science in society and governmental support of science. (Brooks 1986, 122–126.)

In 1944 President Franklin D. Roosevelt asked the director of the Office of Scientific Research and Development (OSRD), Vannevar Bush, to set up a committee to study how the lessons learned in OSRD could be applied in peacetime. The resulting report, *Science the Endless Frontier*, became the cornerstone of American postwar science policy. The report recommended that public funds should be used to support basic research in universities and that science should be given a high degree of self-governance and intellectual autonomy. In return, the benefits of science would be widely diffused throughout society and the economy. (Ibid., 124–125.) The report laid down two major ideas about science. First, it introduced the idea of science as a public good, and second, it put implicitly forward the idea of a so-called linear model of innovation. These ideas were widely accepted as a model for thinking about relationships between science and society also in the other Western countries. (Baldursson 1995.)

Theoretically, the idea of science as a public good was forwarded by seminal analytical work by Nelson and Arrow, who introduced the idea of 'market failure' in the behavior of firms investing in scientific research. Their basic aim was to understand why firms systematically under-invest in basic research, i.e., why perfect competition fails to achieve an optimal allocation of resources. The answer was that the 'public good' nature of scientific knowledge produces a 'free-rider' problem, and as a consequence, firms choose a lower amount of investment in research activities than is required by social optimality. New research findings were thought of as a public good on which society as a whole would be able to draw. Even though it is difficult to measure whether company financing of basic science is below the socially optimal level, the 'market failure' argument has been the central economic rationale for the public funding of science since then. (Dasgupta & David 1994, 490–491.)

For decades after World War II the generally accepted model of innovation was the 'linear model of innovation'. This model explicitly and implicitly dominated much of the theoretical debates and science and technology policy formulations. In the model, basic research produces theories and findings that are redefined in applied research, tested in development processes and after that commercialized as industrial innovations. Each level in the linear model produces outputs that are transferred to the next level as inputs. The flow of knowledge is also unidirectional, i.e., later stages do not provide inputs for earlier stages. (Kline & Rosenberg 1986, 285.)

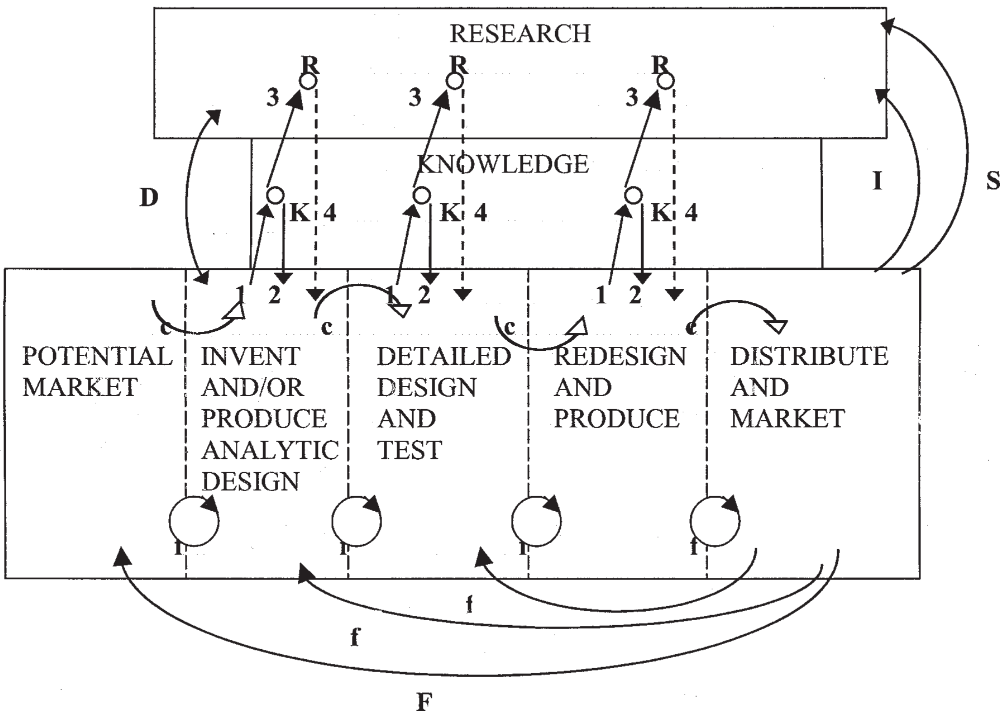
The linear model together with the idea of the 'public good' character of science laid the basis for academic autonomy. As innovations were seen as resulting 'automatically' from basic research, there was no need for enhanced political intervention into the scientific realm. On the contrary, this would have been seen as a distortion of the functional research system, as the researchers were seen as the best experts in their own business – in research. (Baldursson 1995.)

As we know today, however, there are many reasons to believe that the idea of a linear innovation chain is oversimplified. In their already 'classic' (David 1997, 234) critique of the linear model of innovation, Kline and Rosenberg developed in the mid-80's an alternative 'chain-linked model' of innovation. Even though their ideas are more or less commonplace today, the basic ideas are worth repeating. In a nutshell they claimed that the linear model distorted the reality of innovation at least in the following ways (1986, 286–288):

- In the linear model there are no feedback paths either within development processes or from markets to development work. However, innovation processes usually include complex interaction among science, technological development and markets. Innovation demands the gathering and storing of different kinds of information.
- It can be claimed that the central process of innovation is not science but design. A design is essential to initiating a technical innovation and redesigns are an essential part of the process. The problems of designing and development can also give rise to new scientific investigations – there is no one way street from science to development work and innovations. This is further emphasized by the fact that science is often dependent on technological products and processes for its advances.
- Scientific research has an important, but more limited role in innovation than the linear model assumes. Most innovations are carried out with already available knowledge – even though usually scientific in nature. It is only when the available knowledge falls short in problem-solving that there is a need for scientific research. Scientific research seems to have an important role when

new radical innovations are created, like semiconductors or genetic engineering, but more common incremental or evolutionary innovations are made usually on the basis of available knowledge, whether scientific or product-related by origin. Many innovations are also based on the cumulative experience and learning occurring in production.

As an alternative to the linear model, Kline and Rosenberg presented a model they called 'the chain-linked model'. The following figure shows the basic elements of the model and linkages within it.



Symbols on arrows: C = central-chain-of-innovation; f = feedback loops; F = particularly important feedback.

K-R: Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic – therefore dashed line.

D: Direct link to and from research from problems in invention and design.

I: Support of scientific research by instruments, machines, tools, and procedures of technology.

S: Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Figure 2. Chain-linked model. (Source: Kline & Rosenberg 1986, 290.)

As portrayed in this model, science exists alongside development processes, as it is used in any stage of such process when needed. Furthermore, science can be divided into two components: known, existing scientific knowledge and scientific research. If a problem is confronted in innovation, the existing knowledge is consulted first. Only if this consultation is not producing results, scientific research is needed. In this view, scientific research is not the initiating step, but a factor that is utilized at all points in innovation processes. The type of science may also be different at various stages of the innovation process. Kline and Rosenberg claimed that pure science is needed mostly at the first stages of the innovation process, either in order to produce an invention or solve problems related to the invention. The research at the development stage can be considered more as a systems study, as it concerns analysis of how components of the technical system function together. Finally, the research that is needed at the production stage is more often process research that focuses on the question of how components can be manufactured at low cost by improving machinery, processes and materials. Scientific research may also produce radical innovations (path D in the figure). Even though it can be claimed that these kinds of innovations are rare, they have major consequences, as they may create whole new industries. As a matter of fact, this is the old linear model, which has been integrated into the model as a special case. Last but not least, there is also a feedback path from the products of innovations to science. For instance, we may think of computers and information technology that currently play a far-reaching role in the advancement of science.

Economically oriented approaches to estimating the impact of science in society have been put forward by several macro-economic studies. In these studies, economists have tried to estimate the economic returns on R&D and science investments. In general, these studies have showed a positive and relatively high rate of return on R&D investments in both private and wider social spheres. Usually the rate of return on private sector investments has been estimated between 20—30 and more widely in society between 50–100. There are, however, several problems in measuring the economic returns on investments in basic research. One of the major problems is that the economic returns in basic research may be realized in the unpredictable future, and the nature of final applications may make it difficult to trace them back to particular basic research investments and compute the actual rate of return. An even bigger problem might be that R&D is merely one factor enhancing technical change. Therefore, focusing on R&D fails to capture many other activities contributing to technical progress. In addition, it can be claimed that since the results of public R&D are multifaceted in society and the economy, there are no reliable methods for estimating the rate of return on investments into publicly funded basic research. (Schibany et al. 1999, 7—11.)

This does not mean that basic research does not have economic effects. Basic research obviously has a role to play in the economy, but its effects are hard to measure due to the complexity of links. For instance, some contributions are direct and others indirect. Academic research may contribute directly to technological problem-solving when it leads to applicable discoveries, techniques and instrumentation. On the other hand, indirect contributions, like researcher training, background knowledge and professional networks, affect similarly business firms' problem-solving capacity. (Pavitt 1998, 797.) Public investments may also affect private R&D spending. Nelson and Rosenberg (1993, 341) have claimed that there seems to be a significant correlation between public investment in R&D and business-funded R&D, demonstrating that public spending on R&D stimulates additional private spending on R&D, instead of substituting for it. Callon (1994) has suggested that government funding for basic research should be seen as a means of stimulating new combinations of relations between organizations and individuals. Since the market tends to diminish the existing variety, leading to convergence and irreversibility ('lock-in' effect), government action is needed to create new technological and scientific options available to firms.

Salter and Martin (2001) have estimated that one can distinguish at least six different types of contributions that publicly funded research makes to economic growth. Basing their view on a substantial number of studies on knowledge diffusion and use, they argue that the following contributions are of importance:

1) *Increasing the stock of useful knowledge*. This is the traditional justification of publicly funded basic research, yet it is obvious that the path from basic research to commercial application is complicated.
2) *Training skilled graduates*. The flow of skilled graduates from universities may be seen as a primary economic benefit for firms. New graduates bring to firms knowledge of recent scientific research, ability to solve complex problems, perform research and develop ideas, even though firms often have to train graduates before they can be employed effectively. The skills acquired during education are a necessary precursor to the development of more industry-specific skills and knowledge. Thus Salter and Martin claim that it is vital that government-funded basic research and student training are conducted in the same institution.
3) *Creating new scientific instrumentation and methodologies*. The problems researchers face in basic research continually force them to develop new equipment, laboratory techniques and methods. Some of these new instruments and methods may eventually be adopted in industry.
4) *Forming networks and stimulating social interaction*. Government funding provides possibilities for researchers and organizations to participate in research and development networks. Public funding may support and generate new forms of interaction among actors in the innovation systems.
5) *Increasing the capacity for scientific and technological problem solving*. Many firms need to combine a variety of technologies, and public research provides an extensive pool of resources from which these firms may draw. Publicly supported research may provide a useful background supply of knowledge.
6) *Creating new firms*. The evidence is mixed as to whether new firms have been established on a significant scale as a result of government funding. Positive examples include firm clusters around such universities as MIT and Stanford.

It is rather clear, however, that these generalizations cannot be applied in every scientific or technological field as such. The economic impact of basic research may vary greatly. Therefore Salter and Martin end up concluding (2001, 527):

> *"The relative importance of the different forms of economic benefit distinguished here varies with scientific field, technology and industrial sector – i.e. there is great heterogeneity in the relationship between basic research and innovation. Consequently, no simple model of the nature of the economic benefits from basic research is possible. In particular, the traditional view of basic research as a source merely of useful codified information is too simple and misleading. It neglects often the benefits of trained researchers, improved instrumentation and methods, tacit knowledge, and membership of national and international networks. It should not, therefore, be used on its own as the basis for policy measures. In short, the overall conclusions emerging from the surveys and case studies are that: (i) the economic benefits from basic research are both real and substantial; (ii) they come in a variety of forms; and (iii) the key issue is not so much whether the benefits are there but how best to organize the national research and innovation system to make the most effective use of them."*

As the above discussion focus on the university-industry linkage, it is important to remember that university-based research and training contribute also more generally to development of society. We may think, for instance, of public services. Employees in public administration are usually educated in universities and also supplementary education is provided by universities' centers of further education. Correspondingly ministries and other public bodies make research contracts with universities and consult researchers in order to get information from society, develop it and create new policies. It is a commonplace that researchers are heard in the parliament, commissions and working groups when new policies are developed. Likewise different kinds of civil society organizations utilize scientific knowledge and research in their activities. Last but not least, academic research may increase our general understanding of society and its culture that, in turn, may help us to act in society.

While this is largely non-profit activity and the end-results of processes are not usually 'products' in the conventional sense of the word, it might be misleading to refer to innovations in this context. If we, however, broaden the scope of the concept, we may speak about 'social innovations', referring more widely to new processes, systemic renovations and refinements. Zapf (1989, as cited in Schienstock 1999, 16) has defined social innovations as "new ways of reaching specific goals and they include new organization forms, new regulations as well as new life styles, that solve problems better than traditional practices do and that are worth imitating and/or institutionalizing. Innovations have to change the direction of social development". While there are obvious problems related to this definition –

for instance, better practices are in many cases a matter of dispute, since there are no clear cut criteria for superiority or the criteria themselves are a matter of dispute – it gives an idea of the huge diversity of issues that can be related to social innovations. The form of these innovations may differ significantly from technological innovations. For instance, Antti Karisto (1999) has discussed social policy innovations and argued that they are strongly associated with discursiveness, resembling paradigmatic changes in science: things are simply seen and done in new ways.[1] It should be emphasized, therefore, that university research and training has multifarious potential connections to societal developments.

The linkages between science and its practical use

In general, the linkages between science and its practical use can be divided into three forms: direct, indirect and mediated linkages. Direct linkage mechanisms establish a direct connection between researchers or research organization and users of knowledge, and are usually the most visible form of linkages. These forms of linkage may include university-industry joint research projects, research contracts from users or more informally, for instance, meetings at conferences. Indirect linkages include, for instance, researcher training, background knowledge and professional networks which affect society's problem-solving capacity. Mediated linkages are structured through science councils, research funding agencies and technology centers attached to universities or through advisory bodies attached to ministries. The mediated linkages facilitate and create possibilities for direct linkages by infrastructures and establishing such funding instruments and criteria that, for instance, presuppose university-industry collaboration. The linkage mechanisms have also consequences for the degree of autonomy of the science system and for how research is conducted and oriented in university departments and research institutes. (Mayntz & Schimank 1998, 752; Pavitt 1998, 797.)

If we look at the university-society linkages from an institutional point of view, these fall into three general categories: research, service/consulting, and education/training (Konishi 2000, 88). The following table presents one possible typology of university-society relationships based on the distinction between collaborative and knowledge transfer modes of interaction. The range of functions stretches from university-based institutes serving societal or industrial needs to seminars and publication exchange (Blume 1987, 12).

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[1] Erik Allardt has criticized this kind of broader understanding of innovations (1997). According to Allardt, new conceptualizations and interpretations should not be seen as innovations. If they are seen as innovations, it blurs the boundary between commercialized knowledge and basic science. The term 'innovation' should be limited to refer to commercialized knowledge only.

Collaborative Research Mechanisms
University-based institutes serving societal/industrial needs
Jointly owned or operated laboratories
Research consortia
Contracted university research
Government-funded co-operative research programs
Knowledge Transfer Mechanisms
Innovation Centers
Patenting and licensing
Continuing education
Science/Technology parks
Consulting
Personnel exchange
Seminars, publication exchange

Figure 3. Forms of relationships.

One of the problems with this kind of institutional approach is that it does not recognize sufficiently informal linkage mechanisms. For instance, Faulkner (1995, 287–288) argues that informal exchanges of information are far more important from industry's perspective than formal arrangements for cooperation. Even the success of formal collaboration can rely on the strength and friendliness of the informal contacts between the partners. The formal collaborations may bring little or no substantive benefit to the company if the personal relations are not strong and positive. On this basis Faulkner suggests that the linkage mechanisms can be classified into informal (existing contacts, new contacts sought out, chance meetings), privately arranged formal (consultancy, research contracts, hybrid institutions) and government-sponsored formal mechanisms (collaborative training, collaborative research, collaborations involving several cooperating firms).

These kinds of generalizations, however, do not pay attention to the fact that the nature and strength of the ties may vary a lot depending on various factors. One example is the institutional basis. It is a commonplace that the most intensive and multi-faceted relationships to industry and government research institutes can be found in technical universities. In traditional, multi-disciplinary, universities the relationships are usually less developed and intensive. Partially this can be explained on the basis of disciplinary differences. Industry is principally interested in technological development and technical universities are specialized in it.

There may be, however, differences in institutional strategies, orientations and cultures as well. In his recent empirical study, Clark (1998) has, for instance, developed the notion of a 'entrepreneurial university' to describe a university's strategic ability and willingness to widen its funding base and orient itself more towards the business enterprise sector and public services by developing cooperation links. Likewise, there may be different development strategies within a given discipline, which are expressions of different perceptions of the ideal and desirable development of that discipline, in turn affecting the way collaboration is developed (Blume 1987).

It is also evident, that the development of university-industry relations may depend on an industry's R&D intensity, its own research facilities and financial possibilities. In addition, it has been argued that the maturity of the technology may affect the intensity of relationships. In a developing stage of a certain technology, university-industry interactions would be more intense than when the technology is mature. There are, however, opposite views according to which the maturing of a technology does not necessarily reduce the importance of university research for industry. (Blume 1987.)

In addition, the role of the public sector may be critical as financier or initiator of specific programs. Some recent surveys indicate that, for instance, EU funding (Luukkonen et al. 1998) may enhance national and international collaboration.

What may be even more important to note is that the relationship between fundamental research and organizations' capacity to use new knowledge is neither unidirectional nor straightforward. Translation of knowledge into innovative products is a rather complex process. Innovation requires knowledge input and a synthesis of knowledge from a wide range of internal and external sources (e.g. Faulkner & Senker 1995). Alongside codified technological knowledge, also knowledge about, e.g., economics, organization and legal matters are needed. In addition, tacit knowledge and skills acquired during work processes, through informal interactions and personnel recruitment, play a crucial role.

Following the idea of the intermediate and complex nature of knowledge flows, Dits and Berkhout (1999, 213–215) have suggested that the relationships between science, technology and innovative products can be generalized into four statements. First, in innovation processes various technologies need to be integrated into one product. Second, in technology development various scientific knowledge inputs need to be integrated into one new technology. Third, one technology may direct as well as facilitate activities in many scientific disciplines. Fourth, one innovative product may direct or facilitate the development of many technologies. Both "many to one" and "one to many" statements focus on scientific and technological knowledge, excluding other kinds of knowledge. The following figure illustrates interaction and two-way flows of knowledge between science, technology and products.

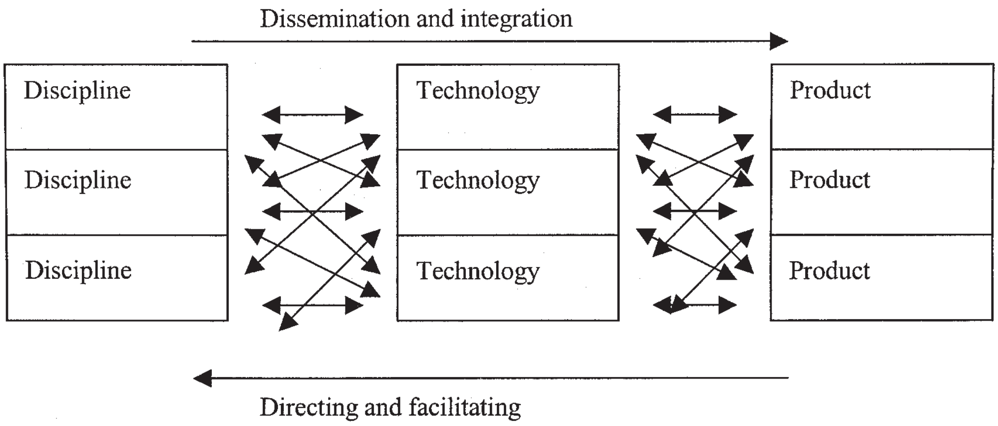

Figure 4. Interaction between science, technology and products. (Source: Dits & Berghout 1999, 214, slightly modified.)

Technological development plays in this schema a 'bridge function' between science and products. Thus, scientific knowledge contributes to product innovation only indirectly. It is possible that direct coupling of the science base to product innovation does not work; rather it needs to be inter-mediated through technology development (ibid., 215–217). The complex interactions at the two interfaces can be seen also as two matrices: as a discipline-technology matrix and as a technology-product matrix. The discipline-technology matrix indicates which disciplines contribute to the research activities in a certain technology, and the technology-product matrix indicates which technologies contribute to the development of a certain product.

Dits and Berkhout's idea of the interaction between the science base and technology and product development shows the complexity of the relationship between scientific research and product development. If we combine this approach with the earlier institutional approach, one possible conclusion might be that the passage of knowledge flows from public sector research to product development is mediated by interface arrangements in which the focus is on development of a technology. If we are going to study the interface arrangements in terms of knowledge dissemination, we should study both interfaces: science-technology interaction (e.g. the knowledge flows from fundamental research to technological development in university-industry joint projects and vice versa) and the use of different technologies in product development.

An interesting, even though very much open, question is whether this schema would be applicable in other sciences, like, for instance, in the social sciences. Is there an equivalent relationship between utilization of relevant social scientific knowledge and its production? At least it seems reasonable to claim that several disciplines may provide information, for instance, in policy formation processes and several policies may affect the formation of a final 'product' that may be, for instance, a certain public service. Whether there is a similar feedback loop as in technical research is, however, a much more questionable argument. While it is not possible to assess the applicability of the schema here more thoroughly, it would be an interesting question to study more carefully.

Analytical framework and data

In general, the connections among various R&D actors and their inter-relations on a macro-level can be protrayed by the following figure. The R&D system is understood as a multi-dimensional matrix which involves three main dimensions: (1) *the institutional dimension* which consists of the various institutional actors and contexts with their distinct R&D profiles and norms (university-based, governmental and industrial research as main types); (2) *the cognitive dimension* which covers the cognitive, substantive spectrum of scientific disciplines and research fields, from hard to soft sciences and from basic research to applied R&D; and (3) *the spatial dimension* which involves different kinds of R&D activities and cooperation at different spatial levels – local, national, macro-regional (e.g. the EU), global – each developing their specific agendas and organizational modes of research. (Kaukonen & Nieminen 1999.)

Institutional structures embody various science-society contracts that are dependent on developments in the larger society, its 'knowledge-intensive' demands and capacity to support and use scientific and technological research. The current institutional structure of science and technology is still based on the three original types of research organization, each having their own historical backgrounds and institutional characteristics. These are: university-based academic research, governmental R&D and industrial R&D. The basic institutional types of research can be located roughly, in the given order, on the dimension autonomous basic research – applied, market oriented R&D, but their relationship is not linear. Rather it might be depicted as a triangle where the institutional locations and interconnections are changing under the influence of intra-institutional dynamics, S&T policies and other socio-economic factors. (Ibid.)

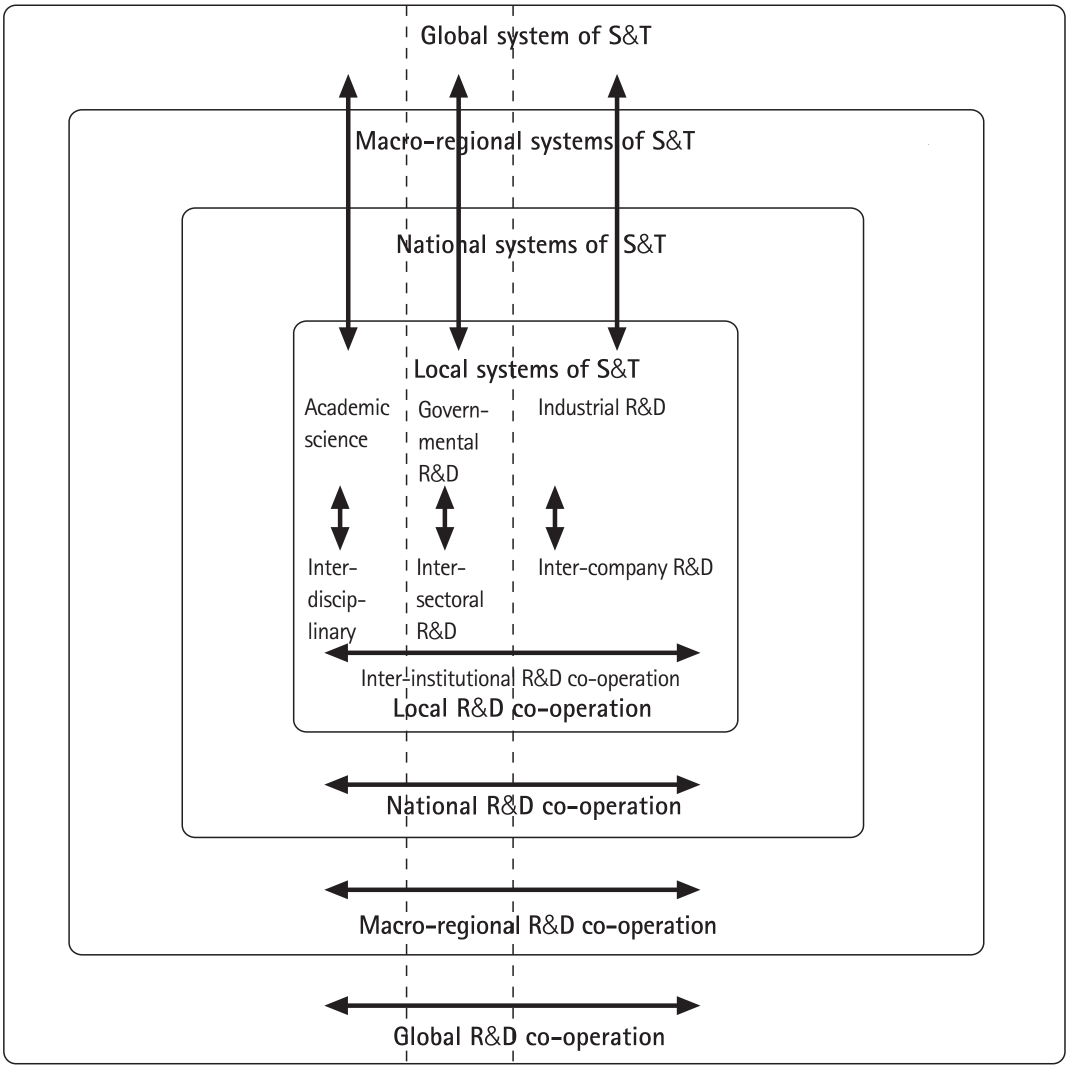

Figure 5. S&T systems, their structural elements and interconnections.

The research interests of different fields as well as their utilization potential are modified in a specific context of relevant relationships. Each scientific field actually has a unique location on the R&D map, with a specific cognitive and social environment in which the researchers create relevant networks for communication and cooperation. In these networks, the relative importance of different orientations may vary greatly between scientific fields. The figure points also to the complexity of issues faced by science and technology policies and to the considerable variation in how institutional configurations and internal linkages in the research system may develop.

The multi-dimensional understanding of S&T systems serves in this study as a heuristic idea that helps us to understand relationships among different institutional actors and levels. The study focuses, in particular, on the inter-institutional aspects of cooperation on the national and local levels, and the perspective is predominantly that of university research. In order to create an accurate picture of research cooperation, the study has exploited and integrated different kinds of approaches from statistical analysis to survey and interview data.

From a methodological point of view, one may analytically define three organizational and activity levels which have been relevant for design and data collection in the study:

a) national actors & policies in the sphere of science, technology and innovation (ST&I),
b) universities and research institutes,
c) university departments and research laboratories/units.

At the national (macro) level the key actors in ST&I policy include the Science and Technology Policy Council, the ministries, Tekes, the Academy of Finland and Sitra. These bodies are mainly responsible for research and innovation policy formulation and the strategic allocation of R&D funding, and partly for policy implementation. Relevant data at this level has included policy documents concerning the developments, priorities and guidelines in ST&I as well as national statistics and indicators on R&D funding and performance.

Universities and research institutes may be characterized as meso-level institutional actors in R&D. On the one hand, they are responsible for the development of their internal research policy and activity, while, on the other hand, they are also to a greater or lesser extent influenced by and involved in the national policy process. At this institutional level data has been selectively gathered from national R&D statistics, strategy documents, and mid-term activity and business plans.

The departments and research units are the actual research-performing organizations that arrange, accommodate and co-ordinate research activities at the micro-level, based on the initiative and activity of individual researchers and research groups. The actual modes of research funding, organization and cooperation vary greatly at this level depending on several factors, such as disciplinary and institutional cultures and human factors (e.g. the role of key persons). At this level, the study has utilized a previously collected survey data, and semi-structured interview data.

In addition, a previously conducted, but unreported, survey on industry-university relationships was utilized in order to include the enterprise perspective. More detailed remarks on the statistical, interview, and survey data can be found in Appendix 1.

3 THE LANDSCAPE OF RESEARCH COLLABORATION

The national policy framework

The development of university-industry-government relationships towards increasing integration is a long-term, non-linear process. The Finnish development features this both on the level of policy concepts and on the level of policy implementation and institutional change. Significant changes both in policy and the research system have taken place within the last three to four decades. The development of Finnish science and technology policy has followed international developments, even though Finland can be considered as a latecomer in the early phases of S&T policy development. (Cf. Kaukonen & Nieminen 1999.) Since it is only possible to summarize some of the main institutional and S&T policy changes here, the focus is on the period from the beginning of the 1990s onwards, which has involved accelerating restructuration of the research system and increasing integration of various policies and institutional settings. First, however, key periods leading up to the 1990s are briefly characterized.

1. The 1950s – early 1960s. A traditional period. Science policy and technology policy are still developing and the universities have extensive autonomy on questions concerning research. The meaningfulness of research for economic development and innovation is, however, recognized and the science policy focus is on extending research possibilities.
2. Late 1960s – 1970s. A period of expansion and social relevance. In the early and mid-1970s, the most valuable attribute of scientific research is 'social relevance' and the advancement of the welfare state and democratic policy objectives. The traditional technology policy begins. It is, however, a quite separate sphere from science policy. The OECD has a strong influence on science policy formulations.

3. The 1980s. The shift of emphasis from science to technology policy. There is, however, no clear integration of science and technology policy. Pressures for the social accountability of science are increasing.
4. The 1990s. A period of technology-driven integration. The relationship between science and technology policy is seen in a renewed way. Science policy and technology policy are integrated. The policy guidelines emphasize use-orientation and the effectiveness of research. The overall concept of a national innovation system is introduced as an official policy concept, emphasizing close interconnections and interaction among various actors in the network of universities, business firms and governmental research units.

As opposed to the earlier social-scientific orientation, in the early 1980s, new guidelines and priorities for science policy were defined. Special attention was now given to basic natural science on the one hand, and to new strategic technological fields on the other. This meant a transition from science policy to broader science, technology and innovation policies. The new technology policy orientation of the 1980´s was consolidated by the establishment of the governmental Technology Development Center (currently National Technology Agency, Tekes) in 1983 and by renaming the national Science Policy Council as the Science and Technology Policy Council in 1986. Also the establishment of the first technology centers (or 'science parks') in the early 1980s can be seen as mirroring the same development.

At the end of the 1980s political attention was increasingly paid to the integration of science and technology as the Science and Technology Policy Council introduced the concept of the national innovation system. Hand-in-hand with the introduction of this new concept, one of the focal S&T policy catchwords of the 1990´s was to become 'networking'. As it was embedded in the concept of the 'national innovation system', networking became an all-encompassing perspective in ST&I policy. As the concept of an innovation system was understood to be very flexible and multifarious, it also made possible a number of policy approaches as well as coordination and concentration of various efforts. Not only technology policy but also science policy, monetary fiscal policies, trade, regional policy and educational policy, among others, were seen to have strong connections to innovation policy. It became an overwhelming perspective encompassing societal progress and 'networking' was seen as one of the preconditions for its functioning.

Special attention was also paid to the position of universities in the system. The Cabinet, for instance, decided in 1993 that "cooperation of the universities will be increased with other parts of the research system, sectoral research and especially with the financiers and conductors of technical research" (Development Plan for Education and University-Based Research 1993). On its behalf, the Science and Technology Policy Council emphasized that "the university system should be developed as a part of the whole research and education system as well as a part of the economic, social and cultural policies ..." (1996, 14). The Cabinet also underlined that research in the universities should be directed to support the development of internationally competitive industries and more funding should be channeled to joint university-industry research projects. Thus, the policy was explicitly aimed at reformulating the position of universities in the research system. While still being considered major sites for basic research, the policy guidelines underlined that universities were no longer separate entities, but an integrated part of the national system of innovation.

Hand-in-hand with the introduction of the national innovation system perspective, the 1990s witnessed other remarkable reforms in Finnish higher education and science policy which can be subsumed under the title of 'new public management' aiming at, for instance, efficiency, decentralization, introduction of market and quasi-market mechanisms, application of performance targets, productivity measurement and evaluation, and increasing emphasis on values like quality, accountability and use-orientation. The new strategy for S&T consisted of a mixture of state, market and academic regulation. The consequences of the new trajectory and coincided recession were seen, e.g., in the changing patterns of university research funding. Public funding was increasingly channeled through competitive funding mechanisms and the criteria for funding from extra-budgetary sources increasingly presupposed cooperation (cooperation within the university system, international cooperation, university-industry cooperation) as a condition for funding. It can be said that the former way to finance universities and other research activities faced a practical as well as a legitimation crisis.

After its establishment, Tekes achieved rapidly a central position in Finnish R&D policy. Already in the 90s it became the biggest single public source of research funding in Finland. Money has been allocated predominantly for targeted technological research. An increasingly important form of activity, beginning in the 1980s, has been the national technology programs which aim at, among other things, networking universities, industrial R&D laboratories and governmental research institutes within the same framework.

Also the Academy of Finland, constituting the Finnish research council system, obtained a more visible and important role in the S&T system. With its funding growing rather steadily through the 80s and 90s, the Academy of Finland assumed a key position in Finnish science policy. Even though the Academy is supporting mostly basic research, there has been a visible shift in funding policy. Applied interdisciplinary research programs have, for instance, gained a more visible status in the Academy's research funding policy. In addition to this, starting in 1993, the Ministry of Education and the Academy launched a program of nominating centers of excellence in university research. The centers of excellence have been selected on the basis of open competition among units. The selected units are rewarded with extra support. Even though the allocated sums have been relatively moderate so far, the centers of excellence policy has gradually taken on greater significance in the science policy. (Academy of Finland 1997a; Academy of Finland 1997b.)

The parallel strengthening of the roles of the Academy and Tekes meant a gradual shift of emphasis in research policy and funding from universities to governmental funding bodies. In the year 1990 the proportion of appropriations distributed by funding organizations of total governmental R&D expenditures was still 42 percent, while the proportion distributed by research-performing organizations was 57 percent. Already in 1996 the proportions turned almost upside down: 52 percent of R&D funding was granted to the funding organizations and 48% to research-performing organizations. (Academy of Finland 10/95.) The technology and competition-oriented policy was consolidated also in the Cabinet's decision on additional funding for R&D in 1997–1999 as it committed itself to increase research funding from the level of 2.5 percent of GDP in 1997 to 2.9 percent in 1999. The additional funding was allocated mainly to the applied, technology intensive fields and channeled primarily through Tekes and the Academy of Finland.

In university policy the roots of the new guidelines were already present in the 1980s. The formal watershed was the renewed Higher Education Development Act. As the original law was passed in 1966 to guarantee the real-term growth in public funding of the expanding university system, the 1986 legislation shifted the emphasis of policy from inputs to outputs. The government called for increasing accountability, evaluation of activities and increasing result-based funding of universities. This led gradually to the reform of allocation principles of funding towards more quasi-market mechanisms. In the beginning of the 1990s, Finnish public administration moved to use lump sum budgeting instead of the former line item budgeting. The lump sum budgeting was attached to the new regulation and funding principles. In 1994 the universities and the Ministry of Education started to negotiate annually a performance agreement. In the agreement, universities and the Ministry of Education agree upon, e.g., a target number of degrees each university should yield annually, its structural development and resources. The operational budget funding has consisted of three parts: basic funding, result-based funding and project funding.

In this same period (the early 1990s), Finland faced a severe economic recession. As a result of general cutbacks in public expenditures, the universities faced a 16% decrease in budget funding in 1993–1994 and universities were forced to concentrate and reallocate funding. As the number of students increased strikingly at the same time and the increase in budget funding was modest after cutbacks, external research funding clearly became more and more important for the universities.

It has to be noted, however, that these developments in the realm of higher education policy did not have any (visible) links to science and technology policy. For historical reasons, links between these two policy realms have been weak, even though the target institution of the policies has been the same.

The focal changes in the Finnish S&T policy during the 90s are summed up in the table below. As it becomes apparent from the table, several changes in S&T policy took place in various dimensions. Even though many of the measures were carried out rather separately from each other, they seem to create a coherent whole aiming at increasing the effectiveness and efficiency of the S&T system. Great importance has to be placed also on new conceptualizations, as they guide new perspectives and ways of understanding the system as well as legitimizing operations. In this sense the most crucial concept in the 1990s was the 'national system of innovation'.

Funding mechanisms

*Shift from line-item budgeting to lump sum budgeting (universities)
*Channeling funding increasingly through funding agencies
*Emphasis on competitive/targeted/program-based funding
*Multi-year budgeting

Development of research activities

*Establishing post-graduate schools, advancing "professional research careers"
*Creating Centers of Excellence system
*Establishing research, technology and "cluster" programs
*Promoting internationalization of research
*Promoting networking and collaboration

Insitutional changes

*Reinforcing the role of funding agencies and increasing co-ordination among them
*Establishing transfer and support organizations (e.g. EU liaison offices, innovation centers)
*Structural development/profiling of universities

Regulation and guidelines

*From detailed regulation to performance-based management
*Evaluation of research and technology
*Emphasis on intellectual property right (IPR)

New conceptualisations

*E.g. "national innovation system", "centers of excellence", "accountability"

Figure 6. Finland: S&T policy instruments in the 1990s.
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Concurrently with the aforementioned changes, the spatial dimension, or international and regional aspects, grew in significance. As for the international dimension, in the 1990s, the internationalization of science and technology was regarded as one of the most important goals of Finnish S&T policy. Especially the role of the European Union became more visible and influential in this respect, not to deny the more general effects of globalization and increasing economic competition. The Science and Technology Policy Council emphasized the importance of cooperation from the perspective of scientific and economic competitiveness. International cooperation was seen as a key element in developing the Finnish innovation system. (Kaukonen & Nieminen 1999.) In 1996 the Council, for instance, estimated that "a major part of the knowledge needed in Finland is produced abroad. The central aim for international cooperation is to acquire knowledge needed in Finland. With the help of international research cooperation, results and knowledge can be obtained which are outside the possibilities of domestic research". (The Science and Technology Policy Council of Finland 1996, 29.)

It is evident that European-level R&D policies have added new trans-national elements to the national R&D matrix, even if their impact varies in different research areas. European-level research activities have expanded in various institutional settings, and taken together, they involve a remarkable share of European research and development (R&D) expenditures. After joining the EU in 1995, Finland actively mobilized the research community to participate in the research, technology and development (RTD) programs, and during the first years of membership, Finland proved to be quite successful in this respect: participation activity more than doubled from the third to the fourth framework program. (Kaukonen & Nieminen 1999.) It is also obvious that EU cooperation increases inter-institutional networking within the research system, as the participating research teams often represent multiple backgrounds, companies, universities and research institutes (Luukkonen & Niskanen 1998).

There are also developments on the regional level that support the international integration of the R&D system. The Finnish government has launched a national program aiming to network local and regional industry, research units, universities and colleges on the basis of regional innovation systems, called Finnish Centers of Expertise. Also the EU's regional policy provides extensive funding for development projects, especially in northern and eastern parts of Finland. Thus, the local aspect has become more integrated into the international aspect through research collaboration among different EU regions. (Cf. Kaukonen & Nieminen 1999.)

To summarize some of the recent science and technology policy changes in Finland, it can be stated that the system became institutionally more diverse and politically more integrated during the last 15 years. The period from the beginning of the 1980s introduced new institutional frameworks that clearly diversified the system. For instance, the establishment of the National Technology Agency and technology (science) parks created new institutionalized forms for technical research. Likewise, the development of European Union RTD policies added a strengthening international dimension to the system and made it more complex. At the same time, however, science and technology came closer to each other, if not intertwined with each other, in policy-making. Especially the notion of the national innovation system created new conceptual tools for understanding the system as a united whole. Still today, however, there seems to be traditional divisions of labor between different ministries and funding bodies, even though recent developments have increased cooperation in policy-making and research funding. The Academy of Finland and the National Technology Agency, for instance, have started to seek new cooperative openings.

Regarding the aims of Finnish S&T policy, cooperation among universities, research institutes and industry became important for policy makers. Concurrently funding mechanisms were designed to support inter-institutional research cooperation. The increasing importance of nation-wide technology programs and the Academy's research programs serve as an illustrative example. An innovation in funding instruments was the creation of so-called cluster programs that aim at, besides multilateral research cooperation, linking various ministries and governmental funding bodies in funding cooperation.

It is evident that this policy has emphasized technological research, natural sciences and applied research in relation to basic research and "culturally bounded" sciences, even though the importance of the latter is, at least, rhetorically recognized. This is evident, for instance, in the concept of the national innovation system that can be considered very much as a 'technology driven' concept, emphasizing the use-value and economic effectiveness of the research.

On the following page a policy-centered organizational map of the Finnish innovation system is presented[2]. The figure reflects our attempt to summarize the complexity of interconnections and number of actors in the national system from the policy-making and institutional perspectives. As the figure illustrates, there is a number of interconnections and potential linkages even at the level of R&D performers. The figure is divided into six activity levels from the general policy framework to goods and service providers. Each level has typical actors, even though several actors, whether policy-making actors or R&D performers, may have functions that cross these ideal divisions.

The Parliament, the Cabinet and the Science and Technology Policy Council are the main bodies occupied with formulating general policy guidelines for the system. The ministries, as decision-preparing bodies, are also partially involved in the creation of general policy guidelines, even though their major functions are to coordinate, allocate funding and supervise the system according to general policy guidelines. Under the ministries are the Academy of Finland and National Technology Agency, which are predominantly R&D financing bodies, but also supervise, coordinate and assess the functioning of the system. At the same time, through this activity, they are involved in facilitating and modulating research institutions. The more innovation-facilitating bodies in this figure include, for instance, Finnvera Oyj, which provides risk capital for start-up companies, and regional employment and economic development centers which, in turn, participate in and initiate regional development programs — some of which are research- and innovation-related. Sitra's role is that of research financing and innovation facilitating, the main focus being on industrial development.

[2] The figure was modified on the basis of an original idea by Orstavik & Nås (1998).

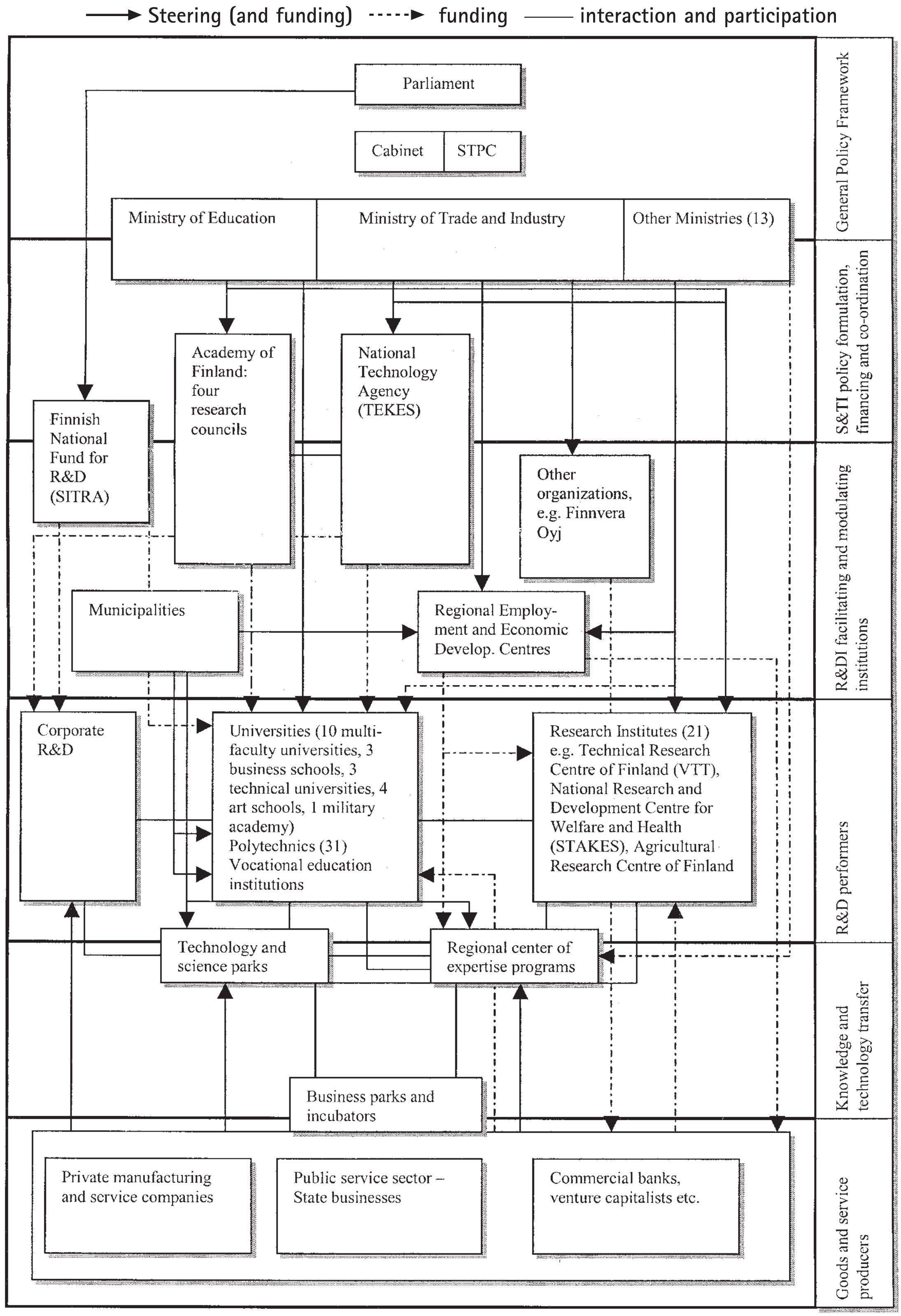

Figure 7. A policy-centered organizational map of the Finnish system of innovation.

Finally, there are the three research-performing sectors, which have several connections to the other parts of the system, whether related to financing or research cooperation. Technology and science parks, and regional centers of expertise programs, for their part, can be considered mainly as knowledge-transfer organizations, even though they are also involved in research activities. Between goods and service providers and knowledge transfer there are business parks and incubators that provide a framework for spin-off companies.

Changes in R&D funding

The following analysis of university research funding two purposes. On the one hand, it gives a general overview of changes in the contextual factors related to university research — of which funding changes can be considered as the most important factor affecting the orientation of research activities. On the other hand, it provides us with a preliminary understanding of the linkages the universities and disciplines have to the surrounding society. The funding flows reflect to some extent the strength of external linkages as well.

Throughout the 1990s external funding of university research increased both in absolute and relative terms. This took place regardless of discipline or university. There are two obvious reasons for this: first, the amount of available external funding increased absolutely, and, second, the universities experienced severe budget cutbacks in the first half of the 1990s and the growth of budget funding was modest after that. Table 1 shows how the total research expenditures increased by 48 percent during the 1990s, but most of the increase was due to a remarkable increase in universities' external funding. During this period of time, budget funding increased only by 18 percent, but there was a 105 percent increase in external funding. The share of external funding of the total research expenditures in the universities in Finland jumped from 33 percent in 1991 to 47 percent in 1998.

	Research expenditures total	Budget funding	External funding
1991	1,00	1,00	1,00
1993	0,94	0,81	1,19
1995	1,07	0,94	1,32
1997	1,32	1,11	1,72
1998	1,48	1,18	2,05

Table 1. Relative changes in university research expenditures 1991–1998, in 1998 prices. (Source: Statistics Finland)

There was a remarkable move upwards in external funding, especially in the second half of the 1990s. This seems to be due to two changes in the funding environment. On the one hand, the national public research funding increased significantly from 1996 onwards because the government launched an additional R&D funding program. This funding was primarily channeled to governmental R&D funding bodies and just marginally to the university budget. On the other hand, EU funding increased significantly starting in 1995 when Finland became a member of the Union. This fact as such does not explain increasing EU funding. At the same time, there was a 'campaign' going on aiming at increasing the internationalization of Finnish science. As part of this effort, Finnish scientists were encouraged to apply for EU funding and a service organization was also established for this purpose. General knowledge on the possibilities for EU funding increased and within a very short period of time a great number of Finnish scientists acquired experiences in EU funding. The following table 2 shows how the significance of different external funding sources changed during the 1990s.

	External funding total 1000FIM	Academy of Finland	National Technology Agency	Ministries	Firms	EU	Other*
1998	1621664	29	23	15	12	7	13
1995	1043458	37	16	16	16	2	13
1991	790574	42	11	16	12	0	19

* Other = municipal funding, other public funding, domestic foundations, international foundations, other international funding, university's own assets

Table 2. External funding of university research by source of funding 1991–1998, in 1998 prices (%). (Source: Statistics Finland.)

The focal position of the Academy of Finland (Finnish research councils) eroded to some extent from 1991 to 1998 as the National Technology Agency (Tekes) achieved more foothold in the universities' research funding. Concurrently, the share of EU funding started to climb up. The 1991 figure is zero because statistics were not yet compiled on EU funding (yet there were some marginal amounts of funding from the EU). The most interesting finding is, perhaps, that the share of university funding by companies suddenly started to decline after 1995, even though the growth continued in absolute terms (from 167 million FIM in 1995 to 197 million in 1998). Most obviously this is due to the significant amplification of

Tekes funding both in relative and absolute terms (in 1995, 169 million and in 1998 371 million FIM). Since the growth of company funding was also significantly bigger from 1991 to 1995 (some 73 million FIM despite the recession) than in the later period, it is possible to conclude that Tekes funding substituted to some extent for direct company funding. If this is true, it is no wonder. Tekes funding may be a more attractive option for both university researchers and companies than direct company funding. For instance, for companies, Tekes funding may provide an opportunity for cost and risk sharing, as they do not have to finance projects alone.

Tekes is, however, a national agent that has a strong role in supporting public-private sector research collaboration. Currently the role of Tekes in networking research and development can be seen as two-dimensional. Firstly, Tekes makes the collaboration possible by providing financing, and creating 'environments' (technology programs) for cooperation. Secondly, Tekes helps potential partners to find each other. In 1998 Tekes was either running or starting, 60 nation-wide technology programs and some 20 smaller programs which gathered around 1 600 participants from firms and 550 participants from research institutes or units. Therefore, direct company funding and Tekes funding as a 'mediator' can be seen as a whole when university-industry partnerships are considered.

The table shows also how the most significant single funding sources for university research are public funding agencies, whereas in comparison companies and ministries have a relatively modest position. However, if the Academy of Finland is considered as the only 'pure' academic research financier, it is possible to think that 'pure' academic research has lost its foothold in the universities and this has meant, perhaps necessarily, the increasing opening up of university research to the society.

Where, then, are various disciplines and universities located on the 'funding map'? Table 3, below, shows the shares of budget funding, external funding and funding sources by university in 1998.

The large technical universities – Helsinki University of Technology and Tampere University of Technology – have clearly the biggest shares of external funding, the biggest individual funding sources being, not surprisingly, Tekes and companies. While in these universities the share of external funding is some 60 percent of total expenditures, in the majority of the universities the level of external funding lies between 40 and 50 percent. This group of universities seems to have the common feature that they have either technical or natural scientific faculties – some of them having also a strong medical faculty. However, alongside big multi-faculty universities, like the University of Oulu or University of Jyväskylä, also the small Lappeenranta University of Technology belongs to this group.

The size of the university does not seem to have any consistent relation to the share of external funding. For instance, Åbo Akademi is a small, multi-faculty university, but its share of external funding is almost half of its total research expenditures. Rather contrary to the Åbo Akademi, the University of Tampere is a relatively large university in Finland but its share of external funding is only one third of total research expenditures. This is perhaps because it does not have a natural scientific faculty and the profile of the university is predominantly social-scientific. An interesting feature is also that the share of external funding in schools of business administration is rather modest, even though their orientation is close to the business enterprise sector. If we look at funding sources, the division is even clearer. Both company and Tekes funding is being funneled more to the technical universities or universities with a technical faculty than to the other universities. In contrast, the Academy of Finland is clearly the more important financier for big and small multi-faculty universities with a natural scientific faculty.

	Expen-ditures total	Budget funding	External funding total	Acade-my of Finland	TEKES	Minis-tries	Firms	EU-funding	Other funding **
TTKK	100	34	66	8	27	3	10	3	15
TKK	100	40	60	8	26	5	12	4	6
ÅA	100	52	48	14	10	7	9	3	6
HY	100	54	46	19	5	9	2	4	7
OY	100	55	45	11	12	8	7	2	5
JoY	100	55	45	18	3	12	3	7	2
TY	100	56	44	19	8	7	3	3	4
LTKK	100	57	43	2	19	6	13	2	1
JY	100	58	42	17	5	6	3	5	6
KY	100	58	42	9	9	6	10	2	6
SibA	100	58	42	7	20	9	1	3	3
TuKKK	100	59	41	9	2	10	7	1	11
TaY	100	66	34	13	2	8	4	2	5
HKKK	100	67	33	11	3	6	7	1	6
LY	100	67	27	4	2	9	0	9	3
VY	100	75	25	2	3	4	3	5	7
SHHS	100	79	21	12	0	6	0	2	1
TaiKK	100	97	3	0	3	0	0	0	0
Total	100	53	47	13	11	7	6	3	6

* Calculation does not include university hospitals and the Drama Academy
** Other funding = municipal funding, other public funding, domestic foundations, international foundations, other international funding, university's own assets

Table 3. Share of budget funding, external funding, and sources of external funding by university in 1998.* (Source: Statistics Finland)

Even though each university would have a unique story to tell about its orientation to external funding, one generalization seems to prevail: universities with a strong orientation to technical, natural scientific or medical research obtain external funding more effictively than the others. Therefore, it is interesting to view the situation focusing on funding from the disciplinary perspective. Table 4 shows the development of universities' external funding by sources and disciplines in the 1990s. The tendency that the Academy of Finland is losing its position as the 'one and only' financier is clear in every discipline. Nonetheless, this it is still an important financier and its distribution of funding is rather even among disciplines, compared, for instance, to Tekes. Its significance varies, however, by discipline. The humanities are the disciplines most dependent on Academy funding while engineering is the least dependent. In a sense, Tekes is a strong substitute for the Academy in engineering, if we compare these two public financiers. In the natural sciences, the significance of Tekes has also increased, but the Academy of Finland is still the focal financier. An interesting feature in Tekes funding is that its significance has grown in other disciplines as well throughout the 1990s. For instance, in the social sciences, the share of Tekes funding has grown from zero to nine percent, and even in the humanities, four percent of the external funding came from Tekes in 1998. Whether this indicates an increasing integration of 'soft science' into technical research is an open question – Tekes does not finance exclusively technical research, but also, for instance, technology policy-related studies.

If we look at the other sources, the ministries' direct funding is important especially for agriculture and forestry, and for the social sciences, as concurrent direct company funding in these disciplines is rather modest. It has to be mentioned, however, that direct company funding has been increasing also in the social sciences (it has concentrated, however, on business administration, whereas Tekes funding is more evenly distributed among the social sciences).

The closest and strongest relationships to the business enterprise sector exist clearly in the engineering and medical sciences. Approximately one fifth of the external funding in these disciplines originates from companies. Table 4 also confirms an interesting phenomenon which was previously observed: the significance of company funding decreased in engineering from 1995 to 1998 as at the same time the significance of Tekes funding doubled. The same phenomenon seems to concern also to a lesser degree the natural sciences. The situation is, however, quite different in medicine where both company and Tekes funding increased significantly in the 1990s. Municipal and other public funding is a rather marginal source in almost every discipline and its significance has increased only a little during the 1990s. In contrast, EU as a financier increased its significance in every discipline. Even in the humanities, its share was almost one tenth of external funding in 1998.

If we summarize what the table tells us about the development of the university-society linkages, it can be said that university research has more contacts with external actors than it had in the beginning of the 1990s. It has to be mentioned, however, that disciplines are in a quite different position if they are compared to each other. For instance, the humanities have less external funding and therefore most likely less external non-academic research cooperation and interaction than the other disciplines.

		External funding total 1000 FIM	**Academy of Finland**	**Tekes**	**Minis-tries**	**Munici-pal and other public funding**	**Domestic and foreign firms**	**Domestic founda-tions and uni.'s own assets**	**EU-fund-ing**	**Foreign founda-tions and other foreign funding**
Natural sciences	1998	596627	35	24	14	6	8	3	8	2
	1995	238439	53	11	14	2	11	4	3	1
	1991	193531	49	12	17	3	8	9	0	1
Engineering	1998	413686	11	40	12	6	20	4	5	2
	1995	393549	16	31	13	6	27	4	2	2
	1991	279422	22	19	15	3	21	19	0	1
Medicine and health care	1998	192742	29	16	10	4	19	9	8	5
	1995	153880	39	8	11	3	17	11	2	9
	1991	119563	49	7	9	3	11	12	0	10
Agriculture and forestry	1998	46035	27	8	32	3	6	5	16	2
	1995	52333	46	5	28	1	4	6	6	4
	1991	34114	54	0	25	1	8	9	0	4
Social sciences	1998	267184	32	9	25	8	9	8	7	3
	1995	139463	43	2	33	5	5	7	2	4
	1991	111946	50	0	26	8	3	10	0	2
Humanities	1998	105390	54	4	18	2	1	9	8	3
	1995	65794	74	3	9	0	0	11	0	3
	1991	51998	76	1	10	1	1	9	0	1

Table 4. The development of university external funding by sources and disciplines 1991–1998, in 1998 prices (%). (Source: Statistics Finland.)

As the funding statistics do not tell us about networking within universities and the content of collaboration, evidence from a recent survey (Nieminen 2000) confirms that university researchers network actively with various actors from domestic and foreign university departments to non-university research institutes and companies, but there are differences in the collaboration profiles. In particular, it has to be emphasized that researchers in the humanities also collaborate actively, even though their collaboration is limited within the academic world. The following table summarizes 'yes' answers to a question in which university department and unit leaders were asked whether researchers from other departments or organizations participate in their department's or unit's research projects.

The table shows how all the disciplines are collaborating actively both domestically and internationally within the university system. Interestingly, international collaboration seems to be at least as important as domestic collaboration and in some disciplines even more important than domestic collaboration – even though practically speaking the differences are not significant. Collaboration with domestic research institutes seems to be also relatively active in all disciplines except in the social sciences and humanities. Actually, the social sciences could be positioned in the middle between the humanities and other disciplines, as almost one third of the respondents collaborated with research institutes. The same pattern is repeated if we look at the collaboration with companies: the humanities have less collaboration with companies than the other disciplines have and the social sciences are occupying the middle position. It is noteworthy, however, that the humanities have some company collaboration as well. In contrast, international company collaboration is centered almost solely around engineering and medicine

Table 5, as well as the evidence from the disciplinary funding patterns, indicates the varying positions of disciplines in relation to societal interests. For instance, as companies are predominantly interested in technological development, also research contacts are centered around those disciplines which are able to respond relevantly to this demand. Since also additional public funding, which has supported networking within the R&D system, has emphasized university-industry relationships and the significance of technical and natural scientific knowledge, the consequences can be seen in the networking patterns and strength of ties. While it is obvious that societal interests and research funding are strongly mirrored in these networking patterns, it is also evident that these differences are also due to disciplinary research substance, orientation and culture – the cognitive and social differences among disciplines. The humanities or social science tradition does not involve, for instance, strong involvement in industrial development. Interestingly, however, there seem to be developments occurring that bring also social sciences and humanities into closer contact with industrial development. It is evident, however, that this development is a consequence of the economic recovery in Finland and increasing public R&D finance – another recession and decreasing public finance might change again partnerships and networking in the whole disciplinary matrix.

'yes' answers of all respondents (%)	Natural sciences	Engineering	Medicine	Agricul-ture	Social sciences	Humani-ties	Multi-discip-linary	Total % (N)
Other departments of our university	65	58	80	90	61	66	84	66 (242)
Other domestic universities	81	58	86	60	66	77	89	72 (263)
Foreign universities	85	58	84	80	64	72	79	71 (259)
Domestic non-university research institutes	50	49	59	90	30	11	68	41 (151)
Foreign non-university research institutes	19	18	12	40	6	7	32	14 (50)
Domestic firms	52	68	55	60	21	10	37	40 (146)
Foreign firms	4	31	39	0	1	2	10	13 (49)

Table 5. Participants from other organizations in departments' or units' research projects. (Source: Nieminen 2000.)

Cooperation in the eyes of researchers

How do the university researchers see the non-academic cooperation; what kind of experiences do they have of it; and how is their research environment structured when the research is done mostly with external funding? These are some of the themes of the following section. Based on semi-structured interviews, the section provides a qualitative and interpretative approach to university-society relationships from the perspective of university researchers.

Research with external funding

Currently, externally funded research is, more or less, taken for granted among university researchers. It seems that since there is currently almost no financing available for research activities in basic university budgets, especially in the empirical sciences and research areas, the funding has to be acquired from external 'funding markets'. In the Finnish universities, budget funding covers mainly the infrastructure and salaries of permanent posts. However, as permanent posts and infrastructure support both teaching and research activities, it is a matter of speculation how much of the basic budget supports research activities in this way. According to the latest university personnel time budget survey, on average, one third of personnel time is spent on research activities (Leppälahti 1993). In addition, e.g., library services, maintenance, and computer centers support research as well. Since there are no precise calculations available on these activities, it is rather difficult to say how much basic university budgets actually support university-based research. The best available aggregate-level approximation is currently the Finnish R&D statistics (Statistics Finland) in which the share is estimated through a number of assumptions and calculations. Even though these calculations can be considered as reasoned, it seems, however, that a detailed study of these issues would be welcomed.[3]

Cutbacks of resources in the universities during the recession in the beginning of the 1990s reduced universities' basic resources (direct budget funding) to a level at which there is very little, if any, space for research activities. If tenured posts and infrastructure are excluded, research is financed practically by external funding from public and private sources. A head of department described this situation as follows:

> *"[p]ractically speaking we could not do any research with those (diminished) basic resources anymore. After that (cutting of resources) all the research has to be financed with external funding, either from public or private sources (...) And the relationships between these (different sources) are the kind of that this funding from public sources, which could be the Academy of Finland, foundations, and also EU-funding, is maybe a little under 10 million in this department, and this special government subsidy (...) maybe some 10 million, and then this research financed by (...) industry, in its different forms, is well over 20 million annually nowadays. So that it is now clearly the most significant external source of funding.*

[3] This can be argued on the basis of two facts. First, the time budget survey that is used to approximate the time spent on research among different faculty positions and disciplines is currently out of date. Remarkable changes have occurred in the universities in the 1990s that might have changed the time budget pattern. Second, the share of infrastructure which is spent on research is estimated both on the basis of the share devoted to research salaries of all salaries in a university and on the basis of the estimated share of services which are directed to research. These estimations can be rather crude.

And if we measure, on this same scale, how much from basic resources is allocated to research in the whole department, it is maybe 1 million."
(Head of department A.)

According to the interview data, in some departments even the teaching infrastructure has to be financed partially by 'profit' they make with their research contracts. Whether all the departments are able to make this kind of 'profit' is, however, questionable: the amount of external funding varies significantly by discipline and department, and the sources of funding may also set limitations to 'profit-making'.

"We have counted that in our department these permanent costs... so that the funding we get through the budget, it still does not cover at the moment tenured posts, teaching, and other things, but some 70-80 percent of it. It means that if there would be no external activities we should kick some (persons) out in order to be able to run this. This system has been tuned to the lowest level possible and, anyway, there has been a certain understanding, as in the whole society was this situation that we had to save in everything, that we have to cut back these resources."
(Professor, department D.)

As a matter of fact, as the amount of departmental basic funding also depends on performance, from this perspective, most of these departments and research units can be seen as small- or medium-sized knowledge-intensive 'enterprises' in which continuity depends on how they manage in 'research and training markets', i.e., how well they manage to magnet research contracts and yield degrees. The interviewees, however, do not complain very much about the situation, but it is seen merely as a fact which cannot be changed and with which they have to live.

It is noteworthy that the interviewees considered projects usually as rather 'academic', in the sense that projects are not strictly development work but the target is to generate more widely applicable knowledge and new ideas on the basis of which partners can start development work. The units and departments try sometimes consciously, in fact, to keep their distance from pure development. In the technical research it is also sometimes considered rather difficult to carry out restricted development projects for firms, since it would require detailed knowledge of processes and technologies in the firms.

These views may mirror the fact that the understanding of the potential and role of university-based research among users of knowledge is not as simplistic or stereotypical as is sometimes claimed. Especially when bigger firms are concerned, it seems that there is developing or has already developed a mutual understanding of the roles of university research and industrial development between firms and university researchers. The development of this kind of relationship has, however, been a long process that has necessitated conscious development of research policy among departments and a new kind of attitude among firms.

> *"It is possible that sometime back in the 70s it was so (that researchers' freedom was limited) but it is not so anymore because companies are quite well aware of — perhaps Nokia and others have taught — that it is necessary to give freedom to the researchers because otherwise nothing new springs up (...) To my mind, in the 70s the companies did not understand at all university research — roughly speaking, only few companies (understood), in the 80s it started gradually to work, and the 90s has been already a (time of) great cooperation (...) But it has changed of course, so that the companies have understood that they have to invest in the universities. And then that if they invest only that kind of money from which they want the whole investment back, it is very shortsighted activity, nothing can be developed. Sure, there is also that kind of research but it is not as fruitful than this kind of long span (cooperation). (...) It could be said, that for a long time it (research) has been like applied basic research and of course it is even now so that the target is "something useful for someone". But, however, all the time it has gone more and more to the direction of studying phenomena (...) So we have gone all the time more and more to the direction of basic research because the industry wants it also. They want to know more exactly how different things in their gadgets function (...) and it is extremely good if the problems come from the industry because if those (problems) are solved then the results "go to the right address" as well ..."* (Professor, department F.)

The same observation seems to hold true in university-ministry relationships. Those interviewees who had cooperated directly with ministries claimed that the administration's attitude towards university research has changed. Administrators value academic research and their role has, in some cases, changed to that of a partner.

It is likely, however, that there would be also different experiences described if the number of interviewees had been bigger. In spite of this, it is an important observation that the interviewees' experiences in both companies and ministries point to the same direction: appreciation of university-based research. It is evident, however, that the development of a new kind of relationship has also necessitated a new kind of attitude and learning among researchers.

> *"[w]hen long ago the relationship between the ministry and research was the kind that they commissioned some studies, and when studies were completed they gave thanks and paid for them - and these studies did not have consequences - now the situation is the kind in which researchers are actively integrated into the ministry's development projects. And it is done so that there has developed, say for researchers... if we in this cooperation suggest that this is something which should be done, this kind of project should be established, so it has usually some sort of*

> *consequences. Now, the administration reacts to it (...) they have begun to see that researchers' message is somehow important and that brushing it aside would be somehow their stupidity and against their business-idea if they are not trying to learn from researchers. There has taken place, step by step, that kind of change and perhaps it is precisely because of this (change) that the cooperation has become more intensive (...) Both parties have learned so that researchers have learned to produce knowledge which is useful in this policy process (...) and then the other way around, they have learned to listen and value the kind of expertise a researcher has."* (Senior researcher, research unit C.)

The relationship between academic basic and applied research can be blurred. The question is of what is sensible and appropriate in different phases of research – the research questions can be both theoretical and practical by nature and the traditional distinction involves as such no intrinsic value. In one phase, research projects can be closer to academic ends and in another phase closer to applications. It is evident, however, that public funding provides, after all, a "freer" framework when fundamental research questions are studied. Direct project funding from, e.g., companies can provide a sufficient funding source when research glides towards application-related questions. This can be interpreted so that public funding is needed as a 'counter-weight' to private contract research financing, and, therefore, as a source of funding for more fundamental and risky questions.

> *"[T]here is a certain amount of that kind of work where public or academic funding is needed more - when new areas (of research) are investigated and related know-how (developed) as free from this kind of project framework which is always more strict by schedule and output. But then, in a way when we move between these areas or transfer knowledge to the other side, as we have created a sufficient know-how potential, then the emphasis can be more on this applied side."* (Professor, department D.)

The interviewees did not actually consider that contract research would seriously contradict their academic orientation or endanger substantively their research. The problem in most cases has been, instead, how to fully utilize gathered data, 'translate' it into academic research and from where to find time for this activity. But there were also some researchers who did not see this as a problem.

> *"But the idea that these contracts would be somehow like substantively in contradiction (...) with academic research, I think it's not true. So that, at least broadly speaking, their contents are such that interest us genuinely (...) The problem is, how in the hell we are able sometime - we have, for instance, a data pile of two meters high of the development of X — so, how could we skim it through sometime and produce something more*

> *comprehensive and utilize those ideas. Of course we have reports on those cases but that kind of meta-reporting would be good. (...) I think it (combining academic aspirations with project work) works rather well, so that research, which we are doing currently, is rather meaningful. But, these people have to make their living in project contracts which are in our unit often very short, like 3–5 months, so it means for a man who is interested in making an academic career, a rather difficult situation. You burn yourself out in project work and then you don't manage or can't do any more academic research. Yes, there is this contradiction, even though we have these models by which we are trying to help academic research, it is still a problem here that how we could combine them better."* (Research unit leader F.)

Strong dependence on external funding sources creates, after all, some problems. The continuity of the research is all the time at stake. For researchers it is backbreaking to apply continuously for funding, as the length of contracts can be rather limited. Attempts to maintain a balance between academic activities (writing articles, academic meriting) and contract research activities may create problems as well. Therefore, project work is very time-consuming for the personnel. Even though project activity may be experienced as satisfying, there is a danger that the workload becomes too big, endangering, at the same time, scientific development. Projects come and go and as deadlines can be rather strict, researchers' time is spent in a continuous 'project treadmill'.

> *"There is like an enthusiastic spirit of voluntary work and working our guts out so that if we all would be tenured professors or lecturers hardly anyone would bother to work this hard. But, at the same time, there is this idea of mindless exploitation here. It is almost impossible for people to find time for reproduction and to read things in one's own area since they have to read each other's project papers all the time. The e-mail is full: would you comment on this? So this is hardly a paradise (...) but there are devilish problems as the question is, how long one stands this, how long it is possible to run this on that basis."* (Research unit leader F.)

Thus, when interviewees were asked as an additional question what they would change in their research environment, they wanted usually some posts which would bring more continuity and possibilities for 'reproduction' in a hectic 'project battle' – like one senior researcher expressed it. This pressure is experienced especially in research units that finance all their functions externally.

This problem relates to maintaining personnel resources, taking the long view in increasing know-how, and to the continuity of research efforts. In technical fields, especially, recruitment of able graduate and doctoral students by collaborating companies may cause problems for maintaining a 'critical mass' in research. On the other hand, recruitment of students or young Ph.D.s means also knowledge transfer from the universities to industry.

> *"And, then, another practical problem (...) is that we have to try to achieve gentleman's agreements that they don't recruit people from the projects at once. It creates here on our side constant discontinuity. As all the time the group changes and becomes younger, it's impossible for us, if we think about creating some new (research) area and creating some tradition, to create a real research group if the people change all the time (...) I have discussed with people from university X and their situation is even worse. At the moment we have some hope to keep a group together some five years but in university X they have already given up. There have been so many disappointments."* (Professor, department D.)

Another problem is post-graduate education. A remarkable number of Ph.D.s in Finland do their doctoral thesis research in research projects. The potential problem is that usually projects do not last long enough for a doctoral student to finish his/her dissertation. In this respect, projects financed by the Academy of Finland are considered 'good' since they usually last longer than, for instance, average industrial contracts. Therefore, a lot of professors' time is spent in hunting for funding for graduate students. This is not necessarily experienced as a problem, even though the threat of discontinuity is always there.

> *"Of course it (the problem of discontinuity) always comes up. It is a fact that the projects are temporary and don't last long enough to finish dissertations. Usually at least two years is needed to finish a dissertation, if there is luck. We try to have these many-year projects so that it (doing dissertation) is easier. In some fields there may be huge problems (...) we haven't had any big problems ... a lot of work, that's what it means."* (Professor, department G.)

All in all, it seems that increasing external funding has had a significant impact on university research. External funding has made it possible to conduct research and 'patched' resource gaps. In general, contract research does not seem to be in severe conflict with academic aspirations, even though the logic of a "project battle" may create problems in the research organization. Short-term contracts and continuous applying for funding create an environment in which a continuous rush and backbreaking workloads shape working conditions. In addition, making a living with contract research may cause instability and insecurity among researchers. Thus, even though external funding has had evident positive consequences for university research, it has also created negative ones. Combining academic goals and the demands of project work is not an easy task and may cause tensions within the organization.

Modes of cooperation and dissemination of knowledge

As presented earlier, the potential modes of university external research collaboration can be divided roughly into two categories: collaborative research mechanisms and knowledge transfer mechanisms. For the group of researchers interviewed in our study, government funded research programs, contract research, and research consortia form the most common modes of research cooperation. Also knowledge transfer intertwines primarily with research cooperation, while almost all the modes of knowledge transfer are in use: departments, e.g., organize continuing education and seminars as well as do consulting for companies and other organizations. One reason for the intertwining of department and research unit-level knowledge transfer primarily with research activities may be the fact that the more organized modes of knowledge transfer are arranged as external to departments in specific organizations (on the university level). Centers for further education take care of professional development, and science and technology parks serve commercialization of knowledge. Besides research project-related activities, departments and research units participate in knowledge transfer through these organizations. Only a couple of units among those studied, for instance, organize extensively further professional education. Other forms of knowledge transfer, like consulting, personnel exchange and seminars, are linked directly to research projects or they do not have that visible a role in departments' and research units' activities.

Even though patent rights are predominantly transferred to the contracting organizations and companies already when a contract is made, researchers also apply for patents of their own and start spin-off companies. This is, however, a laborious and expensive procedure. Therefore, there are currently several experiments going on in order to support and facilitate researchers' patenting in universities. An interesting example is an initiative that has been organized recently at the Tampere University of Technology. The university, in collaboration with the Tampere Technology Center, provides researchers with a service that encourages them to cooperate with already existing companies in commercialization of knowledge. While the usual procedure was previously that researchers have set up companies of their own in order to commercialize knowledge, now researchers are encouraged to make licensing contracts with companies. The patent rights stay with researchers but the system allows them to continue their research work without going into business. In this system, researchers are also provided with financial support and expert services in commercialization.

In many units there has been 'talk about' personnel exchange, but, for many reasons, it has not been carried out. In some units a personnel exchange might cause suspicions among partners; in some other units researchers have considered such an exchange difficult to carry out in a project framework. Companies and other organizations have not been very interested in this possibility either. While there does not seem to be any major obstacles to personnel exchange, it does seem to be 'just one of those things' which has not been engaged in within departments and research units.

Furthermore 'hybrid-groups' do not seem to operate either (researchers from several organizations, i.e., universities, research institutes, ministries and industry working in a joint research group) which would blur the institutional boundaries between partners. In some cases partners have a functional division of labor: certain parts of projects are carried out in different organizations. However, contacts among partners are usually rather intensive: ideas are shared and help given when needed. Also joint articles are written if partners have a common interest in that.

Besides project reports, seminars, complemented by consulting and personal visits, seem to be the major form of knowledge transfer in contract research. There may be different forms for seminars but a common denominator is intensive and thoroughgoing discussion of the project-related questions. For instance, as in the firms people are usually busy and it is difficult to find common time for discussions, the researchers may go to the firm in order to discuss the project and its results. In that way, employees of the firm have an opportunity to clarify unclear matters and ask questions of researchers. The interviewees also considered this way of interacting as practical. A professor analyzed the transfer of tacit knowledge:

> *"That tacit knowledge, there is a lot of it, and I think it's increasing all the time (...) Well, one way is, of course, that a company gets that researcher on its payroll — but that is, from our perspective, an undesirable solution – at least it should not be a standard solution. (...) The other is that the researcher consults for a while for that company. So that he supervises and transfers it (knowledge). (...) And we have had after Tekes projects kind of company-specific seminars, a couple of days. There we have skimmed through that job and collected some 10-20-30 persons there — depending on the need. There we have short presentations and there is a lot of time for questions and discussions. (...) There is a possibility to talk just about those issues that are interesting from that company's perspective. That is also because of the fact that if there would be people from many companies they would mistrust each other. So, that is how we have done that."* (Professor, department E.)

And a research unit leader described the usual way to disseminate research results:

> *"We have done it so that we put researchers out there. They go to that company and gather that crew – not only the research manager or the members of a steering group, who visit here all the time — but their researchers and designers. And they go through these things there, this is the way to create conversation and questions."* (Head of research unit A.)

The same mode of action is common in research that is financed by, for instance, ministries or local governments. Progress in and results of projects are discussed in steering groups, and there are informal meetings between researchers and the most active partners. Seminars and workshops are also a common way to disseminate project results.

These modes of knowledge transfer, however, seem to suit rather well predominant modes of research cooperation. Seminars, organization specific consultations and personal contacts are considered efficient and appropriate on the one hand, and it would be hard to imagine any realistic alternative to them, on the other. It is, however, a bit surprising that university researchers and their partners rarely compose joint research groups. The current practice seems to underline the separateness of activities in various organizations. University researchers study phenomena and conduct 'applied basic research' while their partners focus on development activities in their organizations.

Public funding, and especially Tekes-funding, has a focal role in these departments and units. Public funding may, for instance, create a kind of core around which the company contacts are intertwined.

> *"And these Tekes research programs, which have been used in the 90s, they have been a good mode of operation from our point of view. I mean that as these bigger complexes are built, industrial interest comes there through Tekes, so that we don't have to organize that by ourselves, but these are selected on the basis of applications. Then these programs have steering groups in which representatives of industry can follow what's going on there (...) Then, perhaps, side-projects have been composed directly with industry which then have had support from Tekes separately."* (Professor, department G.)

This seems to be a rather common situation in many departments, and maybe a natural one, as the amount of available public R&D funding has increased significantly during recent years. Public research funding and programs are also valued in the universities. This is understandable, perhaps, from the two complementary perspectives discussed earlier: first, in comparison to direct company (or ministry) funding, public finance may provide a freer framework in which to conduct research. Second, public project and program funding may last longer, and provide a more stable basis for the research enterprise, than sporadic contracts with the private sector. In addition, public funding may also 'balance' various research functions (from basic to applied) and organizational activities (research, education, services) to which the departments and research units have dedicated themselves. Thus, the public funding core makes it possible to maintain several functions more flexibly than if there were only private research funding.

> *"Yes, this role of public funding is significant, as it is maintaining and bringing something new, so that this continuity would start to suffer with (mere) company funding. These projects with public funding are, however, lasting longer and they give better continuity than company funding."* (Professor, department D.)

Many interviewees were also convinced that the participation of a public financier or partner had created additional value in their research effort. Besides financing, public actors may provide researchers and knowledge users with a framework for networking. For instance, regional initiatives may network public or semi-public actors, university researchers, and companies.

> *"The role of public actors is very important here, so that without public actors this would have gone in a totally different direction, and from our part it would have been a different thing. I don't believe that something like this would have emerged without it, because after all our research focus is on the areas which are not directly utilizable economically (...) they are not direct business applications. As a matter of fact, public actors have made these private actors work together in this area quite well. If we think of our research projects (...) they are really good for the companies as they sit in the steering groups and suddenly they realize that they can do business together in this area (...) and these (contacts) wouldn't exist without a public actor."* (Head of research unit A).

But, naturally, the activities of public financiers were the target also of critical comments in our interviews. It seems that researchers view especially program funding with mixed feelings. On the one hand, such programs have many good attributes but, on the other, they may be interpreted as narrowing down the domain of 'free research financing' and, therefore, also researchers' freedom to conduct research in areas they consider important.

> *"The only thing which has been a problem in Tekes funding recently is that a greater proportion of funding is tied to these technology programs. I mean that this free project research it has decreased significantly and it means for us that if you're not exactly within the range of these technology programs it is more difficult to get funding even for good projects just because of that."* (Professor, department D.)

All in all, the landscape of external research cooperation seems rather 'conventional'. Cooperation takes place mostly in the framework of contract research and public research programs. These modes of operation create also a kind of core around which the focal modes of knowledge transfer are attached. Active communication among partners either in the form of visits, meetings, reporting or seminars lays the basis for knowledge transfer. There are no tricks by which tacit knowledge could be disseminated either. In the process of communication, parts of tacit knowledge are constantly codified and transferred to receivers. Companies also hire people from research projects in order to guarantee knowledge transfer. Therefore it is perhaps a bit surprising that there are no joint research groups (or they are very rare) that would create appropriate possibilities for the transfer of project-based tacit knowledge.

A network as a resource

In order to be successful in 'research markets' researchers need a wide variety of contacts – a network in which research information and cooperation possibilities are exchanged. The existence of a network means also that a department's or research unit's partners pass their experiences of research cooperation along in their acquaintance network. Ultimately this means that researchers who are dependent on external research financing have also become dependent on networks in which the reputation of their research unit may be in a decisive position when decisions on financing and cooperation are made. As cooperation means interaction among people, personal relationships and 'good chemistry' become the most valuable social capital for researchers as they develop their individual or unit research programs.

> *"So it's like personal relationships, that these are like more than pure business relations. This (work) is based very much on peoples' personal relationships (...) they have created contacts which go beyond work or projects."* (Head of research unit A.)

It is evident, however, that usually the development of trust-based business relations does not come at once. It may require years of cooperation or acquaintanceship. Sometimes it is entangled also with a department's history and the activities of previous professors and researchers. Likewise, the whole orientation of a department may be dependent on leading professors and on their attitude towards external research cooperation.

> *"Of course it has been strongly dependent on the persons. Professor X, who in his time set up the whole department, he had all the time this kind of strong orientation to external funding (...) So that this current generation, taking care of issues at the moment, is in a way a continuum of those activities - that is the way we are used to take care of business. Of course this current professor generation has created its own profile and each one has his own contacts. There are also certain regular customers for whom a lot of work has been done. It is always such a long-term process when we start to have research cooperation with industry ..."* (Professor, department D.)

There are also indications that the way to establish relationships with contractors has changed during the 1990s. Still in the beginning of the 1990s it might have been rather common that a contractor called a professor and asked whether the department would have been willing to conduct an R&D project for them. Even though there were such structures which in the current vocabulary could be called 'networks', the interviewees with long experience thought that they had less significance than currently. The reason for this may be rather simple: as the significance of external funding has increased and there are a lot of external partners in a number of projects, the future partners are either found in this group or new contacts are passed through these relationships.

> *"It is more this networking currently. Well, there comes these totally new contacts one or two in a month and some of them go further and some not. But even these are usually the kind of comments that "I heard from somewhere, saw somewhere, or I was in a seminar where your guy talked about this". So, in reality that is also about this networking. That kind of pure thing, which came in past years, that someone called the university's telephone exchange and asked who is the professor who would know about this and this issue, that kind of (contacts) come very rarely, only a few in a year. Typically they are some inventors who would like to have some back-up. That kind of old-fashioned contacts come very seldom. So that they are always the kind of (contacts) that in some way the information has circulated. And then, as we have all the time a certain number of projects and there are these people hanging around, so with these people we have all the time contacts. Then, even if we are developing something new, it is quite natural that we contact first these people and ask: what do you think about this, are you interested in (...) The basis is, to my mind, in reality active project work. If we wouldn't have that, it would be a little bit like searching, on both sides. But we have that project activity."* (Professor, department E.)

The same professor considered that also the new ways of communication have helped to bind and create contacts. As an example he compared the current environment, in which research plans and papers are delivered conveniently as e-mail attachments to (potential) partners, to the one ten years ago when "putting up a project needed a lot of personal meetings, explaining and consultation". It is evident, however, that this kind of working method requires a lot of mutual trust.

Mutual trust of partners is one of the focal conditions, if not the primary one, for functional and interactive cooperation. But, development of trust requires, naturally, time. For instance, participating companies may observe a researcher – what s/he does and how s/he does things – before they start to trust him/her. It seems also that in any case mistrust cannot be abolished among participating companies, of which some are competitors with each other. A researcher, however, may be able to create a trusting relationship with each of the participants if companies believe that the researcher is not 'leaking' their business secrets to other companies. Again, however, personal relationships may play a crucial role.

> *"But in the beginning, every time a new project starts, hardly anyone trust each other and then cooperation is very superficial. It is like that companies are waiting without doing anything and waiting that the researcher creates knowledge. But when you get a certain trust, it goes*

> *other way round, so that researcher waits there and gets know-how and help. To my mind it is based on trust. So, the longer you were able to continue this, the better results you would get. (...) I've noticed, however, that there is a fear that their know-how is running out of their control. Especially these domestic companies that are trying to do product development, so that ... you get that trust to a certain person, but if they change persons, we have to start all over again. So it's personal."* (Senior researcher, department H.)

Networks and partners may have a significant role also in project design. Many times projects are developed in cooperation with partners. The original idea may come from a research group or from 'network', but after that it is discussed among potential partners. It could be said that researchers stimulate some parts of their network at this stage as they start to cultivate the idea. A researcher(s) (or head of the unit) contacts potential financiers (public or/and private) and other potential research partners in order to find out who would be interested in participating in the project. As soon as interested partners are found, the process goes further with discussions about the subject of the project. The target is specified and several interests are tied together as the original idea is adapted to fit into the interests of the partners. After that a specified plan with a budget is made and the project may start as necessary funding decisions are made. Even though the details of the process may vary, it is usually rather interactive.

> *"In principle we have a certain basic process how we do it. When we start to compose a project, then we perhaps do that (composing) first here or perhaps with a certain company partner (...) and then we go perhaps to discuss a little with Tekes, so that how does this feel, could this fit in a certain research program, would there be some funding for this. Then we start to look around what kind of company coalition there would be, and who would be interested in it. And then we make the first round in companies when we discuss with these potential companies. We discuss openly that research area and what kind of future prospects there would be and what the interesting research objects would be. And usually there comes, in interaction, that this is a good thing, yes, but have you thought about these areas that could still be involved, or have you taken into account this perspective (...) From this process (...) the research plan develops. (...) Then a paper is made and we will see which companies really come along. We'll make a budget, then we'll see which companies participate and get a commitment that they will pay this, they will participate in this project."* (Head of research unit A.)

Sometimes a research group may have a relatively strong position in project negotiations, as contractors do not have any clear idea how the project would be conducted. Researchers may define research problems and design a research plan that is then discussed with contractors.

> *"So that it is not just a joke that these partners which come to suggest (project cooperation), or they have some sort of research need, that their (project idea) is very unspecified. It is exactly here when this significance of team-work comes, so that it is not only us, but some others (from the unit) who start to discuss with these potential contractors. In fact, in that we consult and define and help them to define what they want. And it is only after that a contract is made (...) Here and now I can't remember any research that we would have been given framework for and instructions that this kind of research is needed (...) but we have mostly ourselves shaped it – both methods and research questions."* (Research unit leader F.)

In a still slightly different model, a research group's cooperation with a contractor may be so fixed that projects are constantly modified and developed in the framework of that relation. In this model the role of financier comes close to that of a research partner. The research group and representatives of the financier actually "sit on the same side of the table".

It has to be noted, however, that the spectrum of research finance and cooperation models is extensive. Traditional contract research, in which the target of research is usually narrowly defined and problems are given beforehand, still has a role in collaborative research. Likewise, at the other end of the continuum 'constrained research — free research', traditional research proposals to research councils and foundations for 'curiosity oriented research' have a significant role as a source of finance. In this context 'interactive project design' has a foothold as a kind of middle model which mediates among various interests. As it was already brought out, departments and research units dislike traditional contract research and prefer contracts which guarantee them more 'elbow room', i.e., which come closer to traditional academic research. However, even though direct applications are not necessarily expected, such research is many times done in the context of applicability: it is 'applied basic research' by nature.

In a more comprehensive perspective, collaboration is usually rather interactive and equal. Financiers are not necessarily passive but rather active participants in research processes and they are also expected to be active. It has to be emphasized, however, that this does not concern the actual research process. Financiers may be actively interested in being informed of the study in its different phases and participating in steering discussions and design, but the study is left in the hands of researchers. There are, naturally, also different cases. Financiers can be rather passive and/or researchers' freedom may be, more or less, restricted.

The benefits of cooperation

The benefits of external cooperation for university research can be divided, roughly, into two groups: First, financial and facility-related benefits, and, second, knowledge-related benefits.

The financial benefits of contract research are significant. Besides the fact that external funding is vital for the whole research enterprise, a project surplus makes it also possible to support – usually rather weak – basic resources in departments and organize academic activities for which there would not be resources otherwise. One example in the sample was a department-attached research unit which had paid with its surplus money rents for the department's fellowship researchers (departments have to pay rent for used space), allowed research grants both for the preparation of research plans and writing articles, and organized academic seminars. The interviewed senior researcher said that with this activity they are trying to "translate quantity of contract research into academic quality". As noted earlier, this is not unusual in university departments: they are 'patching' resource deficiencies with their contract surpluses.

Sometimes researchers have also managed to create such long-lasting and reliable relationships with their partners that those companies allow them to use their testing and laboratory facilities when needed. From the perspective of the research group, this practice creates financial benefits because they do not have to build the same kind of facilities in the university, and the company may benefit as it may utilize the results later in its development work. However, these kinds of relationships are more likely rare and often the utilization of company facilities is related to a project the company in question finances. Companies may also provide researchers with different kinds of technical devices or chemical compounds which are needed in the research process. For instance, a professor told how a company produces a certain kind of electrical devices for them. Now the devices are produced for the department for free, but without this collaboration they should order them from somewhere and pay for it. All in all, it seems rather common that companies let university researchers use their facilities if such facilities exist and are useful for the research enterprise. These kinds of benefits are, however, restricted to the technical, natural and medical sciences.

> *"[I]t (networking) is also financially beneficial. If we think now, for instance, that we have this (firm X's) laboratory and testing facilities in use there. So, that if I now call there and tell them that my researchers will come there to study this phenomenon in their test laboratory (...) then, at once they have the first free time there, the researchers get there and it does not cost anything. So, in practice, it is a kind of extra investment, so that we don't have to build here that kind of testing (facility) and invest millions of Marks in that. (...) And then there is nothing like "if you come here, we want something". They don't want it that way, but as we write and have a lot of projects, there comes*

> *knowledge out and then they are closer to utilizing it than some competitors out there."* (Professor, department F.)

The flow of knowledge is not a one-way street from university research to the companies or other utilizers, but cooperation creates an evident knowledge impact on university research as well. Besides financial opportunities, external collaboration provides access to knowledge that would otherwise be difficult or impossible to reach and diversifies the knowledge production framework outwards from the disciplinary context. Therefore, one side of the coin is financial and the other knowledge-related. On the basis of interviews, it is possible to sketch six different knowledge effects.

1. Cooperation provides up-to-date knowledge on the business enterprise sector's technical development. At least in some cases, obtaining this kind of knowledge would be difficult without collaboration. The business enterprise sector's technical knowledge is usually protected and kept in secrecy from outsiders. Access to this kind of knowledge may also provide for wider understanding of some technical or physical phenomena.

   > *"This is the way how we keep ourselves up-to-date regarding trends in enterprises: where we are going; what kinds of needs there are."* (Professor, department E.)

2. Economies of scale. Collaboration with large companies and other organizations with substantial R&D facilities provides university researchers with a wide knowledge production framework. Relatively small research groups in universities may utilize a wider network of expertise and benefit from that. Collaboration may also provide researchers with such knowledge (e.g., owned by a company) that would otherwise require years of research work. Also public actors (like ministries and local authorities) may provide a 'knowledge production network' that helps in research efforts.

   > *"We get more volume to this job through this way. We are awfully small actors, we have some 3–5 persons or 10 persons in a group to conduct research in some (research) domains here, and so it is negligible on the global scale, a totally marginal thing. But if there is company X with us (...) From there comes a lot of things that are (important) for us; we would not get that knowledge otherwise. (...) If we wouldn't get that basic knowledge, we should possibly work for five years first in order to get to that starting level we get now at once."* (Ibid.)

3. Related to 1 and 2, access to a partner's tacit knowledge and a possibility to anticipate future developments on the basis of this knowledge. This knowledge may also help to anticipate the future needs of a partner or, more widely,

developments in a research domain. This knowledge may be technical, organizational or procedural, and which may be non-salient for an outsider.

4. Partners may pass information on new contacts and potential other partners, which benefits the research effort. New partners may provide researchers with knowledge and/or offer an opportunity to widen the funding base in departments and units. This mode of action can also be called 'network extension', as the actors are widening the reach of their network through this way.

   "[T]hey pass contacts to me, for instance, so that when they hear in administration X that in Brussels they are doing this kind of thing, they tell me. That is something that would be impossible for me to find out by myself." (Senior researcher, research unit C.)

5. Partners may provide access to data or databases that would be possibly expensive or even practically impossible to attain otherwise. One example in the sample was a database being so large and difficult to compile that it would have been impossible without the contractor's financing and collaboration with Statistics Finland. Corresponding examples are privately owned chemical compounds in the chemical industry.

6. In general, a chance to study interesting and important phenomena. For instance, many natural and physical phenomena occur in different contexts and applications. Collaboration with companies offers an opportunity to study these phenomena. The benefit is both financial and knowledge-related. The same may concern also social scientific and other research. A research unit leader from a social scientific discipline said that:

   "We have done a lot of that kind of research here with external funding, which, we think, should have been done anyway, but there would have not been possibilities for that by means of traditional academic funding." (Research unit leader, research unit F.)

Thus, it seems that both financial or facility-related and knowledge-related impacts of external collaboration are important, if not crucial, in some cases for university research. External financing serves, at the minimum, to maintain and continue the research enterprise and creates also surplus value that can be utilized for other academic purposes. From the substantive point of view, however, the collaboration may be in some cases even more important. Access to up-to-date developments and knowledge on the industrial side is important especially for technical research. As for the 'network effect', it may be important in all collaborative research. Partners provide information on knowledge sources and pass along information about other potential partners. Also access to data may be easier through collaborative relationships. However, collaborative research relationships are not all without problems, as we can see in the following section.

Problems in collaboration

As part of the interview, the interviewees were given a list of potential problems in collaboration and asked to point out from the list or otherwise explain what kinds of problems they possibly have had in their collaborative relationships. The perspective being that of university research, the list included, for instance, such items as financial dependency, power relationships, knowledge/technology transfer, secrecy policy, communication problems, leadership, and intellectual property rights (for a more detailed list, see Appendix 2).

In general, there does not seem to exist any major problems in research cooperation as such. The interviewees did not experience, for instance, that financiers would try to steer their work too much by using their power as financiers. The secrecy of research results has not been a problem either. It is "only a matter of negotiation". Sometimes companies want to defer the publishing of results, but the maximum delay among interviewees was six months. Quite the contrary, a typical problem stated in the interviews is that there is not enough time to publish results.

> *"It is just couple of times now we have come across this that it has been said that nothing is allowed to be published. But it is more a matter of negotiation, that we can disconnect these issues in many ways from those (industrial) connections and are able to publish parts of it (...) On the other hand, we have had more a problem that we have more results which we could publish if we would have time."* (Professor, department D.)

Communication and culture-related problems in collaboration might occur when partners' backgrounds are far away from each other. These problems reflect deep cultural and orientation-related differences among persons who have different educational backgrounds, professional experiences, action models, preferences, and values. It seems that the problems are not, however, overwhelming. Partners can learn from each other.

> *"[w]hen we discuss in the unit's projects, not only with contractors, but with partners as well, who don't know our language – the language of social scientific research – and we don't know their language either – whether it's administrational or technical language – then there has been clearly these language problems. Sometimes we have made research plans that, to our mind, have been bloody exact and then people from the technical side say that they don't get anything out of it. Like: what are you actually going to do? (...) It relates exactly to culture and*

> *expectations. There are these people who hunger for curves and quantitative analysis. (…) But that perspective of cultural learning, I think it is important (…) so that that is a real thing: differences of perspectives, of traditions and of approaches in the background. In that sense (…) these kinds of collaborative projects are important from the point of view of learning (…) I have that kind of feeling that in meetings of some projects groups, when we have had an opportunity to discuss about issues, there has taken place sometimes that kind of eureka-experience which happens in alien cultures. "* (Research unit leader, research unit F.)

Communication problems, however, are not necessarily related to different cultural backgrounds, but to differing working habits and conditions. There may be differences even within one and the same company. A professor told how they do not have any problems in communicating with a company's R&D department, but problems may emerge as soon as the partner is from the business unit of the same company. Expectations and working conditions may differ within the same company so much that it mirrors back to research cooperation. Sometimes even the way to express things may cause tensions between the project group and contractor.

> *"Then it can be caused by company culture, and, of course, it can be on our side also. So that they have collaborated with a research group from another technical university or generally with a group from a (governmental) research institute and they are accustomed to (that) and we do it a little bit differently. (…) Many times it depends on rather small things, it may be dependent even on the way to put things. Sometimes we come across the situation that we have a researcher, and in some steering group meeting he shows on a transparency that there "it" is. But there is a representative from a company who wants there to be a 10-page written report on that. And that researcher sees it as a waste of time that he has to explain so-called self-evident facts, so that there it is in one curve and a normal person sees it directly. (…) Many times when I have noticed problem situations they have been like this and we have tried to fix it then."* (Professor, department E.)

Problems do not necessarily relate to differing working habits, but rather to personalities. A crucial factor in a functioning relationship is so-called 'chemistry' between persons, as already was mentioned. This may cause problems not only between contractors and researchers, but between participating university departments and research units as well. An interviewee told how their unit had to break, in agreement with contractors, collaboration with another department, since it would have caused problems for the whole project. Almost every interviewee emphasized the importance of 'chemistry' as a basis for good collaboration.

> *"And this chemistry (...) it is one of the primary things. Even if some person had extremely good expertise, if we see that we can't cooperate with him then it's not worth trying, but it's better to find such an alliance which creates a network in which you know that with them it works and we can do things together."* (Professor, department D.)

In general, it seems that these kinds of problems are commonplace in every collaborative relationship and they are not experienced as serious. One might say, "minor problems are business as usual". One explanation might be, as some interviewees brought out, that the nature of collaboration has changed during the 1990s. Partners or contractors have begun to understand the nature of research and its requirements nowadays better than they used to and therefore also the possibility of conflicts of interest has become smaller. Another reason might be that cooperation is not done with partners which are known as abrasive. Many years of experience with different partners 'filters' functioning relations from non-functional ones. An additional explanation for the absence of problems might be that almost all the interviewed persons represented units that have relatively long experience in collaboration and, therefore, they are able to see and solve potential problems before they become critical.

Intellectual property rights form, however, an exception. They are usually experienced as problematic for one reason or another. Even though the most experienced departments and research units do not have any major problems, patenting and intellectual property rights seem to be such a new issue that some researchers feel the current situation is unclear. Even though a researcher would be experienced in external cooperation, it does not necessarily entail that he would be experienced in protecting his property rights. The commercialization of research results may provoke uncertainty.

> *"It is because this is a new thing for me and a kind of academic paranoia strikes. Especially the thought that we have an idea for equipment, how we could make it work as soon as we conduct these experiments and research. So, if a big international company realizes that, aha, there is an interesting concept here (...) it can easily slip over to them, in a way passing us by. So that there is this fear ..."* (Professor, department A.)

It is also possible that patenting does not occur to researchers and when it does, mistakes in procedure may take place.

> *"And then X from company Y came and saw that (equipment). He said that, oh, patent that at once and start to sell it and he will buy at once one of these for Y. Then we got this idea that, wait a second, patent! It did not even occur to us earlier. We asked a patent agent here and he studied the device, like yes, it is possible to patent this he said. Here is a simple and good idea and since there are no devices of this kind, let's patent it.*

> *Well, his first question was, have you published anything on this. I then brought happily this journal in which we had had an article. Then this agent shut his briefcase and said that let's forget the whole thing; it cannot be patented any more since there has been this article. This was a terrible shock for us; we had this kind of good invention but we were not allowed to patent it."* (Senior researcher, department H.)

Most likely property rights may be the biggest single area where conflicts between researchers and contractors may emerge, since innovation means potential economic value. The experienced departments and units, however, seem to be rather well aware of potential pitfalls; they, for instance, emphasize the significance of formal contracts as a backup if problems emerge. This is perhaps due to the fact that some of them have had their lesson in property rights. However, in the contradictory situations, the financier's power to continue cooperation (and funding) or stop it may weigh more than the legal right to the invention, as the following citation indicates.

> *"Yes we have had (problems with property rights). Therefore we have learned so well. We had once a real problem. We once made an incredibly fine invention, and then, one of our partners took it since it related to their machinery technology. We did it here, not with that company's funding and even the inventor was not on the payroll of that project but in this house (...) the timing of that (invention) was wrong in the sense that we had anyway a certain project going on with them and they regarded it as a result of this project. (...) Then, what was right in that? We discussed with lawyers enough so that they said that we would win this undoubtedly. But, what is a win? I think that a win was that we made peace and didn't start to argue, and they have been a good partner for us after that."* (Professor, department F.)

It is obvious that in disputes over property rights, companies may use successfully their financial power. Especially, if a company is big and a significant financier of research, researchers may back off in order to maintain financing. Another interviewee told how there recently emerged an argument between a research team and a company on patent rights. The argument developed to the point that the rector of the university and the director of university administration had to participate in negotiations. Finally, the company made an announcement that if the researchers wanted to hold to their claims, the company would stop its cooperation with the university and withdraw its funding. The conclusion was that the researchers dropped the case in order to maintain the status quo.

As a whole, it seems that researchers polarize into two groups: those who are more experienced in and aware of property rights issues and those who are not. In addition, university research liaison officers do not see the general situation as unproblematic as departments usually see it. Especially the juridical details of contracts may be often erroneous and often researchers do not understand what kind of issues contracts should include. But then firms do not understand either that university practices may be different from those in the business enterprise sector.

> *"They might have negotiated about it for a long time and there are enormous mistakes. One thing is these properties, to whom do they belong…payment flows is usually one thing which is not, especially if there are several financiers, unambiguous. I mean, there may be almost on any level in that contract parts which seem strange to the companies. They don't understand, for instance, if we want that kind of condition there, that if they get all the other rights, we will get rights, for instance, to utilize those research results in other studies, which is something our researchers don't understand themselves, how important it is for them that we get these kinds of conditions there."* (Research liaison officer A.)

> *"[a]ll of them have their own problems. In contract negotiations there are big problems, so that parties achieve mutual understanding. It's only bargaining, but it takes time. In some cases there can come these kinds of (problems) that it is necessary to refine it for a long time (…) Problems which come to me are related to applications and contracts so that it is necessary to negotiate, and interpretation and checking is needed (…) Maybe there are then these differences in opinions, which can arise concerning the targets of research. I think that they are not disputes but differences in opinions."* (Research liaison officer B.)

Even though it is possible that research services are inclined to overemphasize the existence of problems, since they are consulted most likely in problem situations, clearly, however, contractual issues are not without problems and the support for research services and liaison officers is needed to solve them. Some researchers also claim more extensive support services from the university.

> *"It (support system) should be something like a person who has a clear understanding how this international innovation system and commercialization of innovations functions (…) And, especially, how one should deal with these big international companies; what kinds of contracts are made, patenting (…) and then, as there are several persons in here, how big a share each one should have in that potential firm. How this is divided, what is the share for that person who has mainly produced the ideas and what is the share for the others who have come here and have done some other parts.(…) And then, how to put up a firm and start it."* (Professor, department A.)

The need for a more extensive support system relates here to another important question: how clear is the university's innovation policy. As in one university, rules and policy are experienced as clear and appropriate, in another university, the situation is experienced as more confusing. Universities have rather different innovation policies and practices. The situation may be experienced as frustrating also by research liaison officers. They meet researchers' expectations and need for advice, but are unable to provide them with appropriate guidance, since regulations are missing. They are also unable to widen and develop supportive activities due to unavailable resources. Research liaison officers claim to be overly occupied by formalities and legalities related to research contracts.

Thus, despite recent attempts to create more precise procedures in the field, researchers may experience the question of property rights as unclear. The prevailing ambiguous situation may also have some undesirable consequences. Some researchers, for instance, see a danger that contract negotiations are prolonged and become complicated if there is no unambiguous conception on the division of rights. Another question is motivation. The current practice in which researchers have an opportunity to utilize commercially their inventions has been seen as giving extra motivation to their work. But, how does a unit leader motivate researchers if patenting is practically extremely difficult? In most cases, for instance, researchers lack financial resources for patenting.

As a whole it seems that more than previously attention should be paid to innovation policy. Even though there has been a lot of discussion on the necessity of precise policy, it should be clearer, for instance, how the potential benefits are divided within the research group that has developed an innovation. Even though these issues were not experienced as a problem in most of the units, it is also clear that there is a lot of confusion and ignorance among researchers who are not that experienced in property rights-related issues.

University-industry relations from the enterprise perspective

Innovation studies have emphasized the significance of firms as 'engines' of the innovation system. It has been claimed, among other things, that most of the commercial innovations do not need a research impact from the universities, since usually innovations are based on existing knowledge. Firms' own knowledge base and ability to combine different sources of information are considered to have a decisive role (e.g. Kline & Rosenberg 1986; Schienstock 1999). At the same time however, governmental policy guidelines and recommendations have worldwide emphasized the crucial role of university-industry collaboration as a source of new ideas and innovations (e.g. OECD 1998; 1996). Some researchers have also come to the same conclusion: collaboration is seen as a source of innovativeness and potential commercial applications (e.g. Etzkowitz and Leydesdorff 1997).

The disposition to collaborate with universities naturally varies among firms. Therefore it is common to talk about 'science-based industries' – like ICT and biotechnology – as distinct from other industries (cf. Pavitt 1984). These industries are rapidly developing and it is claimed that their competitiveness is largely based on new scientific knowledge. Likewise talk about 'low-tech industries' refers to industrial branches that do not invest very much in R&D and usually do not own in-house R&D facilities. In reality, the distinctions are not necessary clear-cut. For instance, Palmberg (2001) shows how in the branches of traditional 'low-tech industries' there is a lot of constant research and development activity.

The nature of research activities may also stretch from targeted technology development to near basic research and, in addition, the knowledge impact by the universities on industry may also be indirect. In fact, it is possible that indirect contributions, like the production of background knowledge and graduated students, are more important economic benefits of public research than direct ones (cf. Salter & Martin 2001; Pavitt 1998). This diversity of activities and processes may explain to some extent the wide variety of sometimes contradictory perspectives on university-industry collaboration.

While the academic debate on the pay-offs of university collaboration continues, firms, however, have increased collaboration with universities. For instance, in Finland the amount of direct industrial research funding in the universities increased between 1991 and 1998 by approximately 103 million FIM. At the same time, funding from the National Technology Agency – that has actively supported university-industry collaboration with its funding instruments – increased even more, by approximately 285 million FIM. Thus, the funding which involves, at least potentially, university- industry cooperation, increased by approximately 400 million FIM.[4]

In the following section university-industry collaboration is scrutinized from the perspective of Finnish firms. We are asking, among other things, the following questions: What kind of differences there are between firms that collaborate with universities and those that do not? How significant are universities as partners in innovation-related cooperation? Why do firms cooperate with universities, and how would they improve collaboration possibilities?[5]

Profiles of cooperating and non-cooperating firms

Perhaps one of the basic questions that should be asked, as we study university-industry collaboration, is what kinds of firms are collaborating with universities? If universities are diverse in their internal structures and cultures, likewise firms are not a homogenous mass. The inclination of firms to start university collaboration may vary for several reasons (e.g. Beise & Stahl 1999).

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[4] In 1991 Tekes financed universities by 86 million FIM and companies by 94 million FIM (indexed to 1998).

[5] The data description and reliability analysis are presented in the Appendix 1.

Not very surprisingly, the type of Finnish firms cooperating with multi-faculty or technical universities seems to be usually high- or medium high-tech firms or knowledge-intensive business service companies that have regular in-house R&D activities. In Table 6 we can see that even though the difference between cooperating and non-cooperating firms is not large in the high- or medium high-tech category, almost twice as many medium low- or low-tech companies are not cooperating with universities compared to those which cooperate.[6] In the knowledge intensive business service (KIBS)[7] category, the majority of firms is cooperating with universities. An interesting feature is also that almost half of the high-tech companies in this sample did not have any university cooperation.

In-house research and development (R&D), however, seems to have a stronger relation to university-industry collaboration than the technological level has. There is a major difference between cooperating and non-cooperating firms measured by the regularity of in-house R&D.[8] Only one fourth of the firms that had regular in-house research activities did not cooperate with universities. The situation is totally opposite among firms that do not have in-house research of their own: only one fourth of these companies had university collaboration. Of those companies that had occasional R&D activities, three out of five did not have cooperation with universities.

An interesting question is therefore, how the regularity of in-house R&D together with the company's technological level affects willingness to cooperate with universities. In Table 7 the significance of the technological level is outlined according to the regularity of in-house research and development. As the table shows, the differences between firms with different technological levels are not significant if the regularity of in-house research is standardized. Therefore, the regularity of in-house research seems to affect more university-industry cooperation than technological level. For instance, medium low- or low-tech companies' propensity to collaborate with universities follows the high-tech companies, depending on the regularity of in-house R&D. Thus, firms propensity to cooperate with universities depends on in-house research and development activities.

	Cooperation	**Total N**
High- or medium High-tech	52	102
Medium low- or low-tech	36	136
KIBS	56	134
Total	48	372

p=0,003

Table 6. Firm technological level and university cooperation (%).

6 Classification is based on the categories used by Statistics Finland.

7 For the branches that belong to this category, see Appendix 1.

8 In the analysis the Chi-Square Test of Independence is used consistently. Only p-values are reported.

R&D performed in plant		**High or medium high-tech**	**Medium low or low tech**	**KIBS**	**Total**
Regularly	No cooperation	29	35	17	25
	Cooperation	71	65	83	75
p=0,142	Total (n)	100 (38)	100 (31)	100 (53)	100 (122)
Occasionally	No cooperation	54	68	50	59
	Cooperation	46	32	50	41
p=0,177	Total (n)	100 (35)	100 (56)	100 (40)	100 (131)
Do not have R&D	No cooperation	63	78	76	74
	Cooperation	37	22	24	26
p=0,346	Total (n)	100 (27)	100 (45)	100 (38)	100 (110)

Table 7. Firm cooperation with universities according to regularity of in-house R&D and technological level (%).

University-industry collaboration is affected also by the research and development intensity in a firm. The greater the number of research personnel and the higher the research investments, the more likely there will also be university-industry collaboration. The firms' R&D intensity was measured in the survey with two variables: the amount of research and development investments, and the number of research personnel. Table 8 shows how the collaboration depends on the firm's R&D investments. Dependency is linear among those who cooperate with universities. The more firms invest in in-house R&D the more they have university cooperation.

1000 FIM	**Cooperation**	**Total N**
≤ 99	47	98
100 - 499	54	65
500 - 999	64	28
1000 ≥	87	56
Total	60	247

p=0,000

Table 8. Firm cooperation with universities according to in-house R&D investments (%).

In the case of R&D staff intensity, the difference is also clear. Of those firms that had low R&D staff intensity (here under 10 percent of total employees and including both part-time and full-time R&D staff), approximately 60 percent did not cooperate with universities, whereas of those firms with high R&D intensity (over 33 percent of total employees), approximately 67 percent cooperated with universities.

Cooperating firms also orient themselves to international markets. Of the firms that did not have any exports, 64 percent did not cooperate with universities, while 80 percent of firms in which exports exceeded 100 million FIM, cooperated with universities. Instead, and perhaps a little surprisingly, the data suggests that the volume of turnover does not have any strong linkage to university collaboration. This can be partially explained by the fact that in the sample there are quite a lot of KIBS firms that are active collaborators, but their turnover is usually under 10 million FIM (in 70% of KIBS firms in the sample), which, in turn, skews the distribution to some extent. If KIBS firms are eliminated, the connection is clearer. In the highest turnover category there are more firms that cooperate with universities than in the lowest category. Another explanation might be that universities are not the primary partners for companies in innovation-related activities; even though there would be resources for external R&D collaboration and services, it is not used for university research.[9]

Neither does the content of innovation activity have a strong linkage to university-industry cooperation. Whether the innovation activities were related to customizing products and services, to making product variations on the basis of customers' needs or to service quality improvements, there were no major differences between cooperating and non-cooperating firms. However, the more important the development of products based on new knowledge or product quality improvement is for the companies the more they seem to cooperate with universities. The result is not, however, unambiguous. There are also a lot of firms that do not cooperate with universities, even though product development or quality improvement has a very significant role in the company's innovation activities.

How should we understand these results? Why does in-house research and development seem to have such a strong connection to university collaboration? The preliminary interpretation might be rather evident. Firms' ability to utilize university-based knowledge may be dependent on their own knowledge capacity

[9] In the questionnaire there was a question concerning the firm's 'external' R&D expenditures and universities' share of it. However, obviously the question was experienced as difficult to answer. As 178 respondents had cooperation with universities, only 63 had answered this question. Also the reliability of the variable can be questionable. Without accounting data the estimation can be very crude. Due to the low response rate and questionable reliability, the variable is not presented here and the question of external R&D investments cannot be elaborated further.

and know-how. The capacity, or we may call it also 'absorptive capacity' (Cohen & Levinthal 1990), varies among firms according to their own research and development capacity. If there is no infrastructure and personnel who would take care of the research and development for the purposes of the firm, it is rather difficult to establish useful relations to universities: the firm cannot utilize the available knowledge. It might be also so that the firms that see the in-house R&D as essential for the development and competitiveness of the firm are also able to value other knowledge sources that might complement their own know-how. However, as we do not know which one was temporally the first – in-house R&D or research collaboration – we cannot say definitely that the direction of the causal relationship is as presented above. In addition, there might also be other factors affecting the structuration of relationships that are not possible to control for in this data. One example is the existence and influence of 'gatekeepers', persons who are screening developments in a firm's R&D environment and affecting decision-making on R&D and research collaboration in that firm (Fritsch & Lukas 2001).

From the latter interpretation it should also follow that the branch of industry has something to do with partnering, since markets and competitive environments are different for different branches of industry. For instance, ICT and the chemical industry should have stronger connections to universities than the basic metal industry, since their products and competitiveness are usually seen to be more dependent on continuous research and development.

Industry's cooperation with universities varies to some extent according to branch of industry in the sample. In instruments and equipment, services, information and communication technology and the chemical industry[10] approximately half of the respondents had university cooperation. The least cooperative branches of industry were basic metal and the category 'other' that includes i.e. food production, textile industry and timber and wood products. Even though the differences are not large, it seems that the differences are also connected to varying R&D intensity among industries. The most research-intensive industries, measured by the regularity of in-house research and development (regularly, occasionally, no in-house R&D), i.e., instruments and equipment, services and ICT, are also the most cooperative branches.

Thus, we might say as a rule of thumb that if a firm is R&D intensive it is also possibly a partner to university-based research. This is not to say, however, that these kinds of firms would cooperate somehow 'automatically' with universities or that they would cooperate exclusively with universities in research and development. On the contrary, universities are but one partner to industry among many others, as we can see in the following section.

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[10] For the classification of industries, see Appendix 1.

(%)	Cooperated	Total N
Instruments and equipments	60	43
Services	57	99
ICT	54	35
Chemical industry	47	55
Mechanical engineering	43	40
Basic metal	38	53
Other	28	47
Total	48	372

p=0,011

Table 9. Companies' university cooperation according to branch of industry (%).

A network of partners

Studies on firm-level innovation processes have indicated that firms utilize many sources of knowledge and know-how in their development work (e.g. Faulkner & Senker 1994). These sources may be both internal and external to a firm. This sample seems to confirm these results regarding external collaboration. Firms have concurrently several collaborative relationships in their innovation processes.

As it has been also claimed, universities are not the most important partners for firms in innovation processes. The following table shows how the companies studied assessed the significance of different partners in innovation-related cooperation. Clearly the most important partners are the customer firms, as over four fifths of respondents considered them fairly or very significant partners. Well behind supplier firms come equipment suppliers and subcontractors, which approximately half of the respondents considered fairly or very significant partners. As the table is organized in descending order according to share of respondents considering a partner as fairly or very significant, the technical universities and faculties can be found in eighth place and the universities in tenth place. Perhaps a bit surprisingly, firms considered the schools of business administration as the least important partners in innovation-related cooperation. No less than 66 percent of respondents considered them as being of no significance in innovation-related cooperation and only three percent considered them fairly or very significant. In contrast, public financing and consulting organizations, like the National Technology Agency (Tekes), seem to have a rather important role in innovation processes. Only one third of respondents assessed them as having no significance and 42 percent considered them fairly or very significant partners. However, the table shows clearly that other firms – excluding public financing and consulting organizations – are the most important partners for firms in innovation networks.

There are no remarkable differences between firms that cooperate and firms that do not cooperate with universities in their estimations as far as customer firms, rivals, equipment supplier firms, and subcontractors are concerned. On the other hand, cross-tabulation of cooperating firms with public finance and consulting institutions indicates that these institutions are clearly more important for cooperating firms than for non-cooperating ones. As 56 percent of cooperating firms considered them as fairly or very significant partners, correspondingly only 29 percent of non-cooperating firms came to the same conclusion.

	Of no significance	Of little significance	Fairly or very significant	Total % (N)
Customer firms	3	14	83	100 (360)
Equipment supplier firms	10	37	54	100 (353)
Subcontractors and material supply firms	15	36	49	100 (353)
Public financing and consulting organizations (e.g. Tekes, Kera)	31	26	42	100 (354)
Other places of business in company	49	11	40	100 (345)
Rivals	24	45	31	100 (350)
Research institutes (VTT etc.)	34	34	31	100 (348)
Private consultancy and development agencies	34	38	28	100 (349)
Technical universities and faculties	41	36	23	100 (348)
Other education institutions (e.g. polytechnics)	35	44	21	100 (349)
Universities	49	39	12	100 (348)
Industrial associations (MET, Setele etc.)	61	31	8	100 (347)
Technology centers (Teknopolis etc.)	67	27	6	100 (347)
Schools of business administration	66	31	3	100 (347)

Table 10. The most important partners in companies' innovation-related cooperation (%).

Interestingly, however, there is a clear difference between companies in their partnership structure if we analyze the effect of the regularity of in-house R&D. Technical universities and faculties, multi-faculty universities, government research institutes, and public financing and consulting organizations are more important partners for firms that have regular in-house R&D. For instance, of those companies that did not have in-house R&D, 49 percent reported that research institutes do not have any significance for them in innovation-related cooperation. Instead, only 20 percent of companies that had regular in-house activities gave the same answer. Correspondingly, the significance of the public finance and consulting organizations diminishes as the regularity of in-house R&D decreases.

In the following table, the relation of regularity of in-house R&D and technological level to partners is studied in detail. The regularity of in-house R&D has a stronger connection to cooperation with several partners than technological level. Especially the fact that regular in-house research activities has a significant correlation to public financing organizations, research institutes, technical universities and multi-faculty universities, seems to confirm the earlier conclusion: collaboration varies according to in-house research activity.

	Regularity of in-house R&D	Technological level
Customer firms	0.145**	-0.014
Equipment supplier firms	0.100	-0.039
Subcontractors and material supply firms	-0.003	-0.235**
Public financing and consulting organizations (e.g. Tekes, Kera)	0.425**	-0.098
Other places of business in company	0.041	0.066
Rivals	0.16	-0.126*
Research institutes (VTT etc.)	0.285**	-0.058
Private consultancy and development agencies	0.107*	0.061
Technical universities and faculties	0.313**	0.080
Other education institutions (e.g. polytechnics)	0.062	-0.063
Universities	0.287**	0.054
Industrial associations (MET, Setele etc.)	0.109*	-0.123*
Technology centers (Teknopolis etc.)	0.198*	0.042
Schools of business administration	0.09	-0.024

*Correlation is significant at the 0,05 level

**Correlation is significant at the 0,01 level

Table 11. The correlation between the regularity of in-house R&D, technological level and partnering.

As public finance seems to be important for these companies as well, it is possible to speculate that public financing provides opportunities for collaboration with the public research system and supports public-private research networking. This conclusion is supported by the fact that half of the respondents had received financial support for cooperation from other sources than from their own companies or universities. The most important financiers were the National Technology Agency (Tekes), the Ministry of Trade and Industry (KTM) and the European Union (EU). Of those who had received funding from external sources, 78 percent had received it from Tekes, 22 percent from KTM and 15 percent from EU.

In fact, the sample suggests that external funding has contributed rather significantly to cooperation. Only 13 percent of the respondents who had received external funding reported that cooperation would have taken place without external funding and 56 percent thought that it had made cooperation broader and easier to start. Thus, in spite of the fact that only 23 percent of the respondents thought that cooperation would not have taken place without external funding, public funding seems to help cooperation, i.e., it's not a necessary but facilitating condition for cooperation. Interestingly, however, there are no significant differences among company views according to size or technological level. Neither does regularity of in-house R&D seem to have a significant connection to company opinions regarding external funding.

(%)	Cooperation would have taken place anyway	Cooperation would have taken place but to a lesser degree	External funding made it easier to start cooperation	Cooperation would have not taken place without external funding	Combination (Ticked two or more)	Total N
How has the external finance affected?	13	32	24	23	8	84

Table 12. Impact of external finance on cooperation with universities (%).

Usually the firms that cooperate with universities also involve another firm, a research institute or some other organization in cooperation. Altogether 60 percent of the cooperating firms also had another partner involved in cooperation (N=196). In most cases the partner(s) were other firms, even though also research institutes and other organizations were involved. Interestingly, the regularity of in-house

R&D seems to have a connection to the number of partners. If the in-house R&D is regular by nature there are also usually other partners involved in cooperation: as the regularity of research and development increases, the more likely it is that there are several research partners.

	Regular in-house R&D	Occasional in-house R&D	No in-house R&D
No other partner	35	48	50
Only other firms	28	30	17
Only research institutes or other organizations	16	14	17
Various partners: Firms, research institutes or other organizations	21	8	17
Total (N)	100 (123)	100 (50)	100 (18)

Table 13. Other partners involved in university cooperation according to regularity of in-house R&D (%).

It seems that the cooperating firms are actively looking for ideas, knowledge and partnerships from several directions. As we recall that such firms usually have better resources and infrastructure to start and benefit from cooperation, these findings combined suggest that there are at least three kinds of ideal types of firms (cf. Pavitt 1984): first, firms that are cooperating with hardly anyone. These firms are most likely small, low-tech enterprises that do not have the time nor money or even the need for R&D activities. The second group of firms is cooperating rather actively with customer firms, subcontractors, etc. cooperation is restricted to the realm of enterprises. The third group is comprised of the active ones, high-tech or KIBS firms which have resources and infrastructure for R&D, and most likely their success is based on the development of science and technology-based products and processes. These firms are active collaborators in several directions, including universities. It has to be emphasized, however, that as these groups are ideal types, the actual groups are internally more heterogeneous. There are, for instance, low-tech companies which are collaborating with universities, high-tech companies that are not, and cooperating firms that do not have in-house R&D.

Why not collaborate with universities?

Why, then, are a great number of firms not collaborating with universities? We have already suggested that one reason might be a particular firm's R&D intensity and related 'absorptive capacity'; the firms that have weak absorptive capacity are not collaborating with universities. Obviously, however, there have to be also other reasons, since there are collaborating firms that do not have any in-house R&D activity, i.e., vice versa: the lack of in-house R&D cannot be the only precondition for not collaborating with universities and absorptive capacity is not dependent only on in-house R&D.

The following table sums up the answers to the question "If your company has not cooperated with universities, what obstacles have there been?" As we can see, a lack of time was the most common single reason why a company has not started cooperation with any university. "Time is money" is, however, perhaps a too convenient way to explain why they haven't cooperated with universities. As such "lack of time" only tells that some other matters are prioritized. Therefore, the other reasons in the following table seem much more interesting. The second most important reason for not cooperating with universities refers to the lack of knowledge and information about the cooperation possibilities. According to three fourths of the respondents, this reason had had at least some significance and almost half of the respondents considered it as a fairly or very significant obstacle. As altogether 90 percent of the firm respondents (N=352) thought also that universities should develop their dissemination of information, the lack of proper information can be considered as a very significant obstacle for starting cooperation with universities.

The lack of resources is, understandably, a more significant obstacle for small companies with a turnover on rather modest level. In the sample, for instance, 54 percent of those firms with a turnover between one and five million FIM considered a lack of resources to be a fairly or very significant obstacle, while only 11 percent of the firms with turnover exceeding 50 million FIM came to the same conclusion. For the companies with a turnover between 5 and 10 million FIM, the same figure was 39 percent and for the companies with a turnover between 10 and 50 million FIM it was 29 percent.

	Of no significance	**Of little significance**	**Fairly or very significant**	**Total (N)**
Lack of time	25	26	50	100(200)
Not aware of cooperation possibilities	25	31	45	100(203)
Don't have resources to pay for services	30	35	36	100(200)
Different time scope of operation	40	25	35	100(192)
Difficult to get contacts with universities	37	34	30	100(197)
Cooperation is unimportant to our firm	30	41	29	100(195)
Bureaucracy	46	33	21	100(187)
No autonomy to start cooperation	72	14	14	100(197)
Have tried but it has not started	85	10	5	100(192)

Table 14. Impediments to university-industry cooperation (%).

An interesting feature is, however, that 70 percent of respondents considered university cooperation at least to some extent as unimportant for their firm. If the distribution of the responses is viewed in this way, the insignificance of cooperation becomes one of the focal reasons not to cooperate with universities. Seen the other way round, of those firms which had not cooperated with universities, only 30 percent thought that cooperation would be important for the firm.

It is difficult, however, to say on the basis of this sample why these firms see university cooperation as unimportant. One obvious reason is the technological level of the firm. The following table shows, however, that medium low and low-tech companies differ only a little from high and medium high-tech or KIBS firms in their opinions. An interesting feature is also that medium low and low-tech companies do not consider the unimportance of cooperation as a significant obstacle as do the companies in other categories. This reasoning might lead us to think also that a firm's branch of industry would have something to do with the assessments. There are not, however, any clear differences between branches of industry in their responses.

	Of no significance	Of little significance	Fairly or very significant	Total (N)
High or medium high-tech	31	34	34	100(58)
Medium low or low tech	26	54	20	100(80)
KIBS	35	30	35	100(57)

p=0,041

Table 15. "Cooperation is unimportant to our firm" according to technological level (%).

Regional dimension and other motives in cooperation

An often-repeated claim has been recently that large transnational high-tech firms utilize and combine different knowledge sources on a global scale. They may, for instance, contract with universities all over the world. It seems, however, that physical proximity is still of importance for the majority of the firms (e.g. Kautonen & Tiainen 2001; Howells et al. 1998). Our sample indicates that companies cooperate often with universities that are located in the same region as the company.

Almost four fifths of those who had experienced university cooperation had one or more partners from a local university, whereas under half of the cooperating firms had partners from other Finnish universities and only approximately one percent of cooperating firms had partners from a foreign university. Considered more closely, especially local or regional universities of technology seem to be important partners for companies. For instance, of the companies cooperating with the Tampere University of Technology, 74 percent are located in the Tampere region and 91 percent of the companies cooperating with the University of Oulu (having a large faculty of technology) are in the Oulu region.

An exception in this regard is the Turku region, where there is neither a technical university nor an extensive technical faculty. The Swedish language university, Åbo Akademi, has a small, non-extensive, technical faculty and the University of Turku has a natural scientific faculty. The situation is mirrored in the cooperation pattern of the Turku region companies. Even though the companies in the Turku region are cooperating with the three universities in Turku (University of Turku, Turku School of Business Administration, Åbo Akademi) they are also actively seeking partners from other universities and especially from the Helsinki University of Technology and Tampere University of Technology. In the other regions the cooperation is more concentrated around local universities.

The following table sums up the references in the survey the cooperating firms made to universities by name (the category "other" was so diverse and small that it is not included). In the questionnaire, the firms were asked to mention the three most important university partners in their innovation-related work. Since most of the firms had more than one university partner, the sum of references is bigger than the number of cooperating firms.

References made to	Turku region firms	Tampere region firms	Oulu region firms	Total %
University of Turku	22	1	2	9
Turku Uni. of Business Administration	18	0	0	7
Turku Academy (Åbo Akademi)	13	0	2	5
University of Tampere	1	13	2	7
Tampere Uni. of Technology	20	62	7	35
University of Oulu	0	3	70	16
University of Helsinki	4	1	4	3
Helsinki Uni. of Technology	20	19	11	18
Lappeenranta Uni. of Technology	3	0	2	1
Total (N)	100 (79)	100 (89)	100 (46)	100 (214)

Table 16. Firm collaboration with universities according to region and university (%).

The table shows also how there are three universities ranked above the others as partners for companies: Helsinki University of Technology, University of Oulu and Tampere University of Technology beat clearly the other universities in their frequency of references. Companies seem to seek predominantly technological knowledge from the universities, as the other universities had clearly fewer references. An interesting feature is also that even though Helsinki University of Technology is not a regional university for these companies, it had a number of references. While this is merely speculation, we can guess that as the biggest technical university it may provide the firms with research possibilities that are unavailable in the other universities; and that its status as the leading technical university may also attract firms. However, as the northern University of Oulu had only a few references outside its own region and as the third 'leading' university, Tampere University of Technology, had references also from the Turku region, it is possible to speculate that the regional proximity of Turku, Tampere and Helsinki in southern Finland explains the distribution of references. On the other hand, the result indicates that the University of Oulu is important for companies in northern Finland.

We can also study this hypothesis a bit more closely. The sample indicates that, as a matter of fact, regional proximity is not the primary motive for starting cooperation with a certain university. Approximately four fifths of the cooperating companies reported that the applicability of the services, universities' active orientation to cooperation and high standard of research are the focal reasons to start cooperation. However, it cannot be said that the proximity would have no significance, since still two thirds of the respondents considered proximity as a significant reason for starting cooperation. There are no major differences among firms in how they appraise different reasons for cooperation. For instance, controlling technological level or firm size does not produce any significant differences among firms. Firms are rather unanimous in their estimations; they are looking for applicability, quality, and active, easy-to-access partnership.

	No significance	Little significance	Fairly or very significant	Total (N)
Services are applicable to our firm	5	12	83	100 (149)
Active orientation to cooperation with firms	3	15	82	100 (149)
High standard of research	3	19	78	100 (144)
Highly specialized research	7	21	72	100 (146)
Research is easily applicable	7	24	69	100 (144)
Previous experience of cooperation	11	24	66	100 (148)
Proximity	14	22	63	100 (152)

Table 17. Focal reasons for starting cooperation with the university department or unit with which the company has cooperated (%).

Cooperation forms, goals and impacts

So far we have, more or less, taken for granted that firm collaboration with universities involves research and development. There might be, however, also other forms of collaboration like continuing education and consulting (cf. Blume 1987). Neither does research cooperation always involve product development, but it may be related to process and organization development as well. Therefore it is interesting to study the potential forms and goals of collaboration a bit more closely.

Our study revealed that, perhaps surprisingly, the most common forms of firm-university cooperation are the writing of masters' theses in a company project, contract research and product development. Approximately two out of five firms had one or more these kinds of cooperation with universities. In contrast, market research and organization/process development are the least used forms of cooperation. Thus, as the following table shows, the cooperation is usually rather product-oriented. The analysis also supports earlier conclusions about the firms' R&D activities: they are mostly technological. Likewise, as the schools of business administration and multi-faculty universities are not usual partners for the firms in innovation-related activities, so are also the least common forms of cooperation those that might be in the expertise area of those universities. Market research and organization development is rather rarely the subject of collaboration. It is also possible that market research services are bought from market research companies and consultants. It is interesting that writing a master's thesis is such a common form of cooperation. We can speculate that a thesis is in many ways an excellent form of cooperation for firms, since it creates possibilities to recruit new personnel and to train and socialize persons into the firm before the actual work starts. In addition, a thesis may be an affordable form for a firm to acquire research and development capacities for some restricted problems, while acquiring the latest knowledge on these problems.

Have had cooperation in the form of:	**%**	**Total N**
Masters' theses for the firm	46	155
Contract research	42	155
Product development	37	155
General exchange of knowledge	31	155
Personnel training	26	155
National and EU R&D programs	19	155
Market research	7	155
Organization/process development	6	155

Table 18. Prevalence of forms of university-industry cooperation (%).

As a whole, the responses reflect the fact that cooperation does not focus only on research activities. University education and its utilization also perform an important function for the companies. Especially students who write their theses in projects for firms seem to represent a meaningful form of collaboration. A thesis is not, however, intrinsically an important goal for the collaboration, but the commercial utilization of knowledge, the acquiring of new scientific knowledge and the monitoring of technological development actually form the most important goals of the cooperation. As the following table indicates, two thirds of the respondents in this sample considered them fairly or very significant goals. This result is interesting also from another perspective. It could be interpreted that knowledge transfer, visions of the latest technological developments and new scientific knowledge are the actual substantive goals that may enhance a company's commercial targets. Commercial utilization of knowledge is an evident target for companies, but they acknowledge that it cannot be achieved without knowledge production-related targets.

The table indicates that companies' university cooperation may involve a wide variety of targets that are not restricted to direct commercial utilization of knowledge. It is interesting, for instance, that two thirds of the respondents had set goals that relate to developing international contacts. We might think that even though university collaboration is limited to regional or national universities, as we saw earlier, the universities may provide a 'door' to international contacts,

	No significance	Of little significance	Fairly or very significant	Total (N)
Commercial utilization	7	24	70	100 (153)
Acquiring new scientific knowledge	11	23	66	100 (152)
Monitoring technological development	9	29	62	100 (150)
Theses	23	17	59	100 (150)
Technology transfer	13	31	56	100 (150)
Training of personnel	22	27	51	100 (154)
Testing and measurement results	25	26	49	100 (151)
New or substantially improved research methods and equipment	17	36	47	100 (149)
International contacts	34	32	34	100 (149)
Cooperation with clients and subcontractors	34	34	33	100 (149)
Joint use of equipment	33	37	30	100 (150)
Testing and making prototypes	44	28	28	100 (149)
Development of software	44	30	26	100 (149)
Fulfilling standards	49	27	24	100 (148)
Sharing risks and costs	40	37	23	100 (149)
Monitoring competitors	37	42	21	100 (150)
Acquiring patents and licenses	72	20	8	100 (148)

Table 19. Companies' goals in university cooperation (%).

especially for small or medium-sized companies. Likewise, it is interesting that more strictly applied targets like testing and making prototypes, development of software and fulfilling the requirements of standards are not as important goals as acquiring new scientific and technological knowledge. The technological level or the firm size does not make any major differences among companies in their estimations of goals. The same concerns the cross-tabulation of the regularity of in-house R&D and goal variables.

Not very surprisingly, the respondents form groups according to the goals they set for the collaboration. This question is examined in the following by utilizing factor analysis. The results of the analysis are presented in the following table. The combination of five factors accounts for 60 percent of the total variance.

The interpretation of the first three factors seems relatively clear. On the first factor high loadings have variables that relate to the acquisition of scientific and technical knowledge. Concerning this factor, the variables 'joint use of equipment' and 'testing and measurement results' have, however, loadings over 0.20 also for Factors Two and Three. Their relation to Factor One is, therefore, less clear and this factor is named 'acquisition of scientific and technical knowledge'.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Acquiring new scientific knowledge	**0.76**	0.00	0.03	0.00	0.13
New or substantially improved research methods and equipments	**0.76**	0.02	0.15	0.03	0.17
Transfer of technology	**0.68**	0.17	0.04	0.10	0.00
Monitoring technology development in the field	**0.57**	0.27	0.14	0.43	-0.22
Joint use of equipment	**0.50**	0.33	0.24	-0.47	0.02
Testing and measurement results	**0.47**	0.39	0.20	-0.45	-0.20
International contacts	0.06	**0.78**	0.15	0.11	0.15
Monitoring competitors	0.08	**0.76**	0.19	0.22	-0.03
Cooperation with clients and subcontractors	0.29	**0.68**	-0.03	-0.07	0.05
Fulfilling the requirements of standards	-0.04	**0.60**	0.38	0.09	-0.15
Sharing risks and costs	0.36	**0.42**	0.33	-0.05	0.05
Testing and making prototypes	0.15	0.09	**0.84**	0.01	-0.03
Acquiring patents and licenses	0.00	0.21	**0.64**	-0.04	0.16
Commercial exploitation	0.32	0.18	**0.44**	-0.09	-0.26
Training of personnel	0.05	0.34	-0.17	**0.64**	0.01
Development of software	0.29	0.10	0.45	**0.62**	0.07
Theses	0.19	0.09	0.06	0.03	**0.89**
Cumulative percentage accounts for	16,9	33,2	44,9	53,7	60,0

Factor names: Factor 1: Acquisition of scientific and technical knowledge; Factor 2: External contacts; Factor 3: Development and commercialization; Factor 4: Personnel training; Factor 5: Students

Table 20. Factor analysis of the goals of university cooperation. (Principal component analysis with Varimax rotation)

In Factor Two, the variables 'international contacts', 'monitoring competitors' and 'cooperation with clients and subcontractors' have the highest loadings and they also seem to relate to each other conveniently. They represent a motivation for external contacts that are not limited to the university partners. Universities may provide opportunities for international contacts, while projects also form platforms for collaboration with close company partners and surveillance of technical development in programs where there might be partners from competing firms. This kind of collaboration seems often to be related to standardization and to risk and cost sharing. One possible explanation is that it is rational and cost-reducing to collaborate even with competitors in order to achieve a situation where there is only one technical standard in the markets. The development of several independent standards costs simply money – not to speak about the possibility that the developed standard will lose in market competition. These variables have, however, relatively high loadings also in the Factors Three and One, i.e., they relate to several factors.

Factor Three can be named 'development and commercialization'. The variables with high loadings refer to activities that relate directly to the development or acquiring of marketable products. Also the variable 'development of software' has high loadings in this variable, even though it seems to relate more clearly to Factor Four and to some extent also to Factor One.

Factor Four is less clear to interpret than the other ones. The variable 'personnel training' has the highest loading on this factor but also 'software development' as well as 'monitoring technology development' have relatively high loadings. In addition, the variables 'joint use of equipment' and 'testing and measurement results' have negative loadings, indicating a contradiction with the aforementioned variables on this factor. Most likely it indicates a difference between 'hardware' and 'software' groups within sample firms. As the 'training of personnel' has the highest loading and the other variables have loadings also on the other factors, this factor is named 'personnel training'.

In Factor Five there is only one variable, i.e., it does not correlate with any other variable. 'Thesis' seems to be a rather independent activity that may relate to student recruiting and training. It does not relate strongly to any other purposes. It has also a negative correlation to 'commercial exploitation' and two variables in the factor 'acquisition of scientific and technical knowledge'.

Cluster analysis confirms that these factors form also distinctive groups within the sample. Only two background variables, however, correlate significantly with these factors: regularity of in-house research and regularity/extension of university collaboration. The regularity of in-house R&D has a connection to the 'acquisition of scientific and technical knowledge' (0,302**) as well as to the 'students' (0,170*).[11] A positive correlation seems to indicate that the more regular the firm's own research activity is, the more interested it seems to be in scientific and technical knowledge and in students' thesis projects. Likewise, a significant correlation

[11] ** Correlation is significant at the 0,01 level; * correlation is significant at the 0,05 level

between regularity/extension of university collaboration and the aforementioned factors (0,329** and 0,385**) indicate the same direction. Those companies that cooperate regularly and extensively with universities are also more interested in scientific knowledge and students than the companies that have only occasional cooperation.

The goals and impact of cooperation may, however, differ from each other significantly. Even though a company would be primarily seeking to commercialize products, the major impact of collaboration might be something else. Thus the respondents assessed that university cooperation had impacted mostly on their particular company's know-how. Product/service quality ranked second while added prestige; employment of new personnel; and improved working methods formed the third group. In contrast, cooperation had clearly less of an effect on productivity, cooperation with other firms, internationalization and market shares.

	No impact	Little impact	Fair or big impact	Total (N)
Increased know-how	3	15	82	100 (154)
Improved quality of product/ services	16	30	54	100 (153)
Added prestige	24	30	46	100 (150)
Employment of new personnel	36	21	42	100 (151)
Improved working methods and process	28	33	39	100 (150)
Increased ease in commercialization of products/services	25	41	34	100 (153)
Added productivity	38	33	29	100 (149)
Increased cooperation with other firms	42	31	27	100 (150)
Increased internationalization	41	34	25	100 (150)
Added sales or increased market share	32	46	22	100 (149)

Table 21. The impact of university cooperation (%).

While it is impossible to judge whether the respondents have thought in terms of either direct or indirect impacts or both, it seems clear, however, that the company's increased know-how, or knowledge, is the most important type of impact of university-industry cooperation. As the two foremost goals for cooperation in companies were commercial utilization and acquiring new scientific knowledge, of the impacts, the knowledge component was emphasized at the expense of commercialization. When companies were asked about their goals in university cooperation, interestingly, added prestige was rather high in respondents' estimations and employment of new personnel scored in fourth place, likewise the writing of a thesis. Even though added productivity, etc. are not that important impacts, it has to be emphasized, however, that university cooperation may have, in some cases, a significant impact on a company's internationalization. Perhaps a little surprisingly, there are almost no differences among firms in their estimations based on size, technological level or R&D intensity.

How do perceived impacts and collaboration goals then relate to each other? This question is outlined in the following table. A significant correlation between goal factor and impact variables should indicate how well the impacts match the goals the firms set for the collaboration. Interestingly, the first two factors correlate with most of the impact variables. The factor 'acquisition of scientific and technical knowledge' correlates not only with 'improved know-how' and 'improved working methods and processes' but also, for instance, with 'cooperation with other firms' and 'employment of new personnel'. It does not have, however, any strong connection to internationalization or commercialization. The factor 'external contacts' correlates with internationalization and 'cooperation with other firms', 'added prestige' and 'added sales' but not with variables that describe direct knowledge-related impacts. The factor 'development and commercialization' is the only one that correlates significantly with the variable 'increased ease in commercialization of products/services'. The factors 'personnel' training' and 'students' correlate with 'employment of new personnel', indicating perhaps, how orientation to education-related cooperation links up to personnel recruitment.

The high compatibility of goal factors and impact variables may indicate that the companies have gotten the benefits they have been looking for. However, it is also possible that the companies see the primary benefits where they have set the goals and therefore the result might be a bit 'biased'.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Increased ease in commercialization of products/services	0.100	0.057	0.218*	-0.102	0.040
Added productivity	0.169*	0.298*	0.029	0.119	0.014
Improved quality of product/ services	0.199*	0.198*	0.104	0.026	0.110
Added sales or increased market share	0.130	0.320**	0.183*	0.116	0.030
Improved working methods and process	0.268**	0.147	0.078	0.073	-0.002
Improved know-how	0.365**	0.104	0.184*	0.043	0.078
Employment of new personnel	0.227**	0.169*	0.199*	0.261**	0.321**
Increased cooperation with other firms	0.279**	0.466**	0.077	0.053	0.153
Increased internationalization	0.084	0.466**	0.259**	0.114	0.167
Added prestige	0.306**	0.451**	0.242**	0.023	0.143

* Correlation is significant at the 0,05 level

** Correlation is significant at the 0,01 level

Table 22. Correlation of goal factors and impact variables.

Are there problems in cooperation?

Perhaps a bit surprisingly, the researcher interviews suggested that researchers do not experience any major problems in collaboration with non-academic partners. How do the firms see this relationship and are possible problems connected to certain characteristics like firm size? From the researchers' perspective there is, for instance, some evidence that conflicts of interest are more likely to take place when research is funded by a small firm (Blumenthal et al.1986). As the fact is, that work in industrial R&D laboratories often differs from university-based research regarding its targets and organization (cf. Kiianmaa 1996), different styles of communication and intellectual property rights, for instance, might be such issues that one would expect to cause conflicts between university researchers and firms.

In this sample, however, no major problems in the cooperation were expressed or they were considered to be only minor ones. From the following table we can see that the problems have concerned usually communication, the inactivity of some partners, their know-how or supply of funding. Even in these cases, approximately two thirds of the respondents did not report any problems. Interestingly, the confidentiality of research results and intellectual property rights have been a problem only for one tenth and one fifth of the respondents and only under 5 percent of the respondents considered these problems as severe. This result seems to support the earlier interview result: obviously there are no major problems in collaboration, as both researchers and companies have the same opinion on this.

	No problems	Minor problems	Major problems	Total (N)
Confidentiality of results	88	9	3	100 (151)
Intellectual property rights	82	14	4	100 (151)
Too many partners	81	18	1	100 (149)
Change of partners' objectives	81	17	1	100 (149)
Reorganization of partners and participating org.	77	23	1	100 (149)
Change of partners	77	21	3	100 (151)
Change of firms' objectives	75	23	3	100 (150)
Different technical standards and solutions	74	25	1	100 (148)
Coordinator's management skills	69	25	6	100 (151)
Too ambitious objectives	67	31	3	100 (150)
Supply of funding	67	25	8	100 (150)
Inactivity of some partners	64	32	5	100 (149)
Problems in communication	63	36	1	100 (151)
Partners' know-how	63	32	5	100 (152)

Table 23. Problems in university cooperation (%).

Factor analysis of collaboration problems reveals that the problems seem to form four groups. The first group is named here 'communication and know-how'. While the explanation for the logical connection among these variables is speculation, it is possible, however, that the first two variables with high loadings relate to communication problems. The coordinator's activity may involve very much arbitration between partners and their interests and thus dependent on his social and communication skills.

The variables with highest loadings on the second factor relate to firms' possibilities to utilize knowledge commercially. Problems in intellectual property rights and the confidentiality of results refer to contractual problems and perhaps also to firms' and university researchers' differing understandings of the use of knowledge. Connection of the third variable to the other ones is again, more or less, unclear. This factor is named 'utilization of knowledge and changing objectives'.

	Factor 1	Factor 2	Factor 3	Factor 4
Problems in communication	**0.812**	0.038	0.091	0.093
Coordinator's management skills	**0.722**	0.328	0.053	0.255
Partners' know-how	**0.693**	0.246	0.175	0.153
Change of firms' objectives	0.369	0.338	0.184	0.368
Intellectual property rights	0.251	**0.737**	0.339	-0.133
Confidentiality of results	0.022	**0.727**	-0.008	0.441
Change of partners' objectives	0.298	**0.638**	0.063	0.198
Reorganization of partners and participating organizations	0.091	-0.036	**0.831**	0.157
Change of partners	0.028	0.399	**0.706**	0.110
Supply of funding	0.343	0.343	**0.536**	0.025
Inactivity of some partners	0.439	-0.118	**0.520**	0.457
Too ambitious objectives	0.136	0.082	-0.015	**0.775**
Too many partners	0.134	0.169	0.264	**0.661**
Different technical standards and solutions	0.462	0.177	0.215	**0.524**
Cumulative percentage accounts for	18.0	33.1	47.8	62.4

Factor names: Factor 1: Communication and know-how; Factor 2: Utilization of results and changing objectives; Factor 3: Reorganization and change of partners; Factor 4: Ambitious objectives and too many partners

Table 24. Factor analysis of collaboration problems. (Principal component analysis with Varimax rotation)

Factor three consists predominantly of variables that refer to problems with changing partners and their qualities (inactivity). The supply of funding might also appear to be a problem under these kinds of conditions if the terms of and possibilities for funding change concurrently with partners. This factor is named, however, according to spearhead variables as 'reorganization and change of partners'.

On the fourth factor, the variables 'too many partners' and 'different technical standards and solutions' may have a logical bearing on each other, as technological knowledge is usually partially 'local' by nature, i.e., firms have different technical solutions and systems that they use. Therefore, if the number of partners increases, this may also emphasize problems that arise from different technical solutions. These problems may also correlate negatively with goal achievement, i.e., the objectives of collaboration are experienced as too ambitious under these circumstances.

Interestingly, the firms do not differ from each other remarkably in their answers. Cross tabulation of the focal background variables and problem variables indicate that there are no clear differences between firms, for instance, according to size. The only and logical exception is the regularity of in-house R&D. In some cases, the regular in-house research firms have more problems than firms occasionally conducting in-house research and firms that do not have in-house research and development activities at all. This seems to be, however, rather understandable. As the regularity of in-house research and development tells also that a firm is most likely collaborating with universities on a regular basis, it is understandable that these firms have experienced more problems than others. The more there are contacts and collaboration, the more likely that problems also occur. The study of correlations of factor variables and background variables gives a result that indicates the same direction. However, it seems that firms with regular in-house R&D have some problems especially with utilization of knowledge and changing objectives (0.190; sig. 0,05) as well as with reorganization and change of partners (0.183; sig. 0.05). Why this might be so is an open question.

There is still one problem that deserves to be mentioned separately: the availability of information. The companies were also asked the extent to which they are aware of university-based research that is relevant from their perspective. As over two-thirds of respondents (N=359) estimated that they were not at all aware of or they knew only a little of this kind of research, the result indicates that companies are seemingly badly informed about university research.

Not very surprisingly, the companies are better informed about university research if they have regular in-house R&D and their technological level is high. As these firms are also those that cooperate with universities, the data suggests easily circular deduction: the firms cooperate with universities because they are aware of university research which is important for them and, in turn, they are aware of this kind of research because they cooperate with universities. These companies also use a wider scale of information sources than non-cooperating companies that rely rather strongly on secondary sources like journals and TV or radio. Thus, for instance, approximately 60 percent of cooperating companies considered seminars and conferences as fairly or very significant sources of information, while only 20 percent of non-cooperating companies gave a similar answer. In contrast, non-cooperating companies considered TV and radio more often as a significant source of information than cooperating companies.

As the foregoing analysis indicated, that the non-cooperating companies considered also the lack of proper information as one of the most important obstacles for starting university cooperation, it might be accurate to claim that there is an information gap between cooperating and non-cooperating companies. The companies that are involved in university research and services are able to accumulate their knowledge of different cooperation opportunities while those who are not cooperating remain uninformed.

4 CONCLUSIONS, INTERNATIONAL COMPARISONS AND POLICY IMPLICATIONS

In this study we have attempted to explore universities' non-academic collaboration from several perspectives. We started by describing and analyzing policy and institution-related developments. The development of cooperative linkages was then studied within this societal framework, building upon three kinds of empirical data. We first analyzed R&D funding statistics covering all the universities and fields of science in order to assess the development of university research from the funding perspective and in order to draw a picture of the research linkages to the utilizers of knowledge, like industry and ministries. The second part of the empirical analysis dealt with university researchers' experiences of non-academic collaboration based on qualitative interview data. The third data set consisted of a company survey aiming at analyzing, for instance, what kinds of companies collaborate with universities and what kinds of targets the Finnish companies set for the collaboration.

In the following, the major empirical findings are summed up and discussed in relation to past studies that have addressed questions similar to those in this study. Some theoretical conclusions are also drawn. In the final part of this section we draw some more general conclusions that may be of relevance for policy-makers.

The changing policy environment and research financing

The idea that university research has an economic function is not a new one. However, even though the history of university-industry collaboration goes back to the late nineteenth century, it has been only since the 1970s that the economic and societal functions of research have gained more visibility and political prominence. Much of the interest in university-industry linkages came from the United States, where several universities had developed close links with industry. The developments in the US were closely monitored in Europe and new collaboration mechanisms were also adopted. (Howells et al. 1998, 12.) In addition, global economic and technological development in the late 1970s and beginning of the 1980s led to new policy formulations in several countries. The influential OECD developed also new policy recommendations and instead of a former problem oriented and wider societal perspective, the emphasis was now placed on generic technologies and strategic (natural scientific) basic research (e.g. Ruivo 1994).

Finland also followed these international developments. The establishment of the new National Technology Agency and the establishment of the first technology and science parks exemplify the policy shift and institutional development of the early 1980s (Kaukonen & Nieminen 1999). However, it was not until the beginning of the 1990s that the university-industry linkages gained more political prominence. The national innovation system as a focal policy perspective and networking were to become the S&T policy catchwords of the decade. From now on universities were encouraged to strengthen their relationships with industry and other knowledge users on the highest political level. Parallel development of information technology and biotechnology sectors served as examples of successful utilization of scientific knowledge for commercial purposes. In addition, it seems rather obvious that the weight of Nokia's R&D was of special importance for the development of the S&T system in Finland (cf. Lemola 1998).

It is possible to state that during the last twenty years the Finnish S&T system became institutionally more diverse and politically more integrated. New institutionalized forms for scientific and technical research (like specific national and regional programs, and science and technology parks) and the development of the EU's RTD policies added new dimensions to the system and made it more complex. At the same time, science and technology came closer to each other and cooperation in policy-making and research funding among various funding bodies and ministries increased.

Furthermore, funding mechanisms were designed to support inter-institutional research cooperation and new emphasis was put on efficiency and effectiveness. As the emphasis of public financing was transferred from core (budget) funding to more competitive instruments, external funding of university research increased both in absolute and relative terms regardless of discipline or university. There were two obvious reasons for this: first, the amount of available external funding increased absolutely, and, second, the universities experienced severe budget cutbacks in the first half of the 1990s while the growth of budget funding was modest after that. Of the public funding agencies, the National Technology Agency (Tekes) achieved more of a foothold in the universities' research funding, while the Academy of Finland still remained as the biggest external financier. Concurrently the share of EU funding started to climb up. Public funding agencies remained, however, the most significant funding sources for university research, as companies and ministries had still a relatively modest position compared to them.

In general, the analysis of research funding indicates that universities have more contacts with external, non-university actors currently than they had in the beginning of the 90s. It has to be noted, however, that disciplines are in a quite different position if they are compared to each other. The humanities have less external, non-academic funding and therefore most likely less external non-academic research cooperation and interaction than the other disciplines. The 'application-oriented sciences' (the engineering and medicine) have most external funding – even though also basic natural and social sciences have substantially non-academic external funding. The sources of financing also vary. Put simply, industry finances technical, natural scientific, and medical research, while public administration is also interested in social scientific knowledge. Thus, the research demand from different sectors of society is directed toward different disciplines. Firms are predominantly interested in technology as a strategic resource, while public actors, like ministries, are interested in the application of policy relevant knowledge in public administration. On the other hand, it is also obvious that disciplines' different orientations and cultures affect the formation of linkages on the university side. The traditional academic ethos of not advancing specific societal interests is also strong in some disciplines. Universities are internally highly diversified and segmented into various 'academic tribes and territories' (Becher 1989) that see their specific functions in different ways, which, in turn, might be reflected in the structures of finance and research cooperation. There are, however, new initiatives, for instance, in the field of social sciences, that seem to show increasing interest towards the business-enterprise sector – even though the relative weight of these linkages is still quite marginal.

Unfortunately, there are hardly any research funding analyses available currently that would make possible proper, up-to-date international comparisons on the level of funding sources or disciplines. Irvine et al. (1990) conducted at the end of the 1980s a seminal study in which they compared at length university research finance in several countries. Their study is, however, out of date and it has not had successors since then. The OECD statistics, for their part, provide interesting information on general trends, but on the highest aggregate level (see e.g. OECD 2000). One obvious reason for the lack of detailed comparisons is that international funding comparisons are extremely difficult due to differences in S&T systems and in the compilation of statistics. Thus, even though the OECD has tried to standardize the compilation of statistics in its member countries, its S&T statistics still include several potential sources of error (Irvine et al. 1990, 3–6). There is, however, one recent study that provides us with some information on how Finnish developments relate to other European countries. Hackmann and Klemperer (2000) studied the development of university research funding in Belgium, Finland, Germany, the Netherlands, Switzerland and the United Kingdom during the 1990s. Even though they do not analyze funding data in a way that would be directly comparable to this study (for instance, definitions of disciplines vary from country to country) and there are also likely errors in comparisons, their work comprise an interesting, general point of reference for the findings of this study.

Hackmann and Klemperer divide funding sources into three 'streams' (ibid., 4). The first stream of funding includes basic or core research resources provided to universities on an annual basis, i.e., governmental budget funding. The second stream of funding is comprised of research resources that are made available to universities via state or para-state research finance agencies. The third stream includes contract funding from government departments, industry, non-profit organizations and international financiers (such as the EU).

In terms of the first stream, the UK is the only country where basic funds comprise less than 50 percent of the overall research financing (in 1998, 35 percent). In Switzerland, Germany and the Netherlands, the level of basic funding is highest (between 65 and 72 percent), as Finland and Belgium remain in between these extremes. The proportionate importance of basic funding has declined in all the other countries except in the Netherlands, where it has remained at approximately 70 percent. The tendency towards decline has been most obvious in the UK and Finland and the least dramatic shift has taken place in Germany. (Ibid., 15–18.) Hackmann and Klemperer's data shows also that public financiers seek greater control over research expenditures. There is a trend towards selective, and thus competitive, funding instruments and mechanisms in the distribution of basic funding in the sample countries. Most notably this can be seen in the UK while Germany and Switzerland are on the other end of the scale. (Ibid., 21–25.)

Concurrently with the decline of first-stream funding, the importance of third-stream funding has increased. The only exception is again the Netherlands, where the share of third stream funding has stayed at approximately 20 percent of overall funding. The most dramatic shifts have taken place in the UK and Finland: in the UK, the share of third-stream funding has climbed up from 32 percent in 1992 to 41 percent in 1998 and in Finland from 16 percent to 23 percent in the same period. The smallest change has taken place again in Germany, where this share increased by only three percent from 1995 to 1997. The proportion of third-stream funding of overall funds is highest in the UK (a bit over 40 percent) and lowest in Belgium (under 10 percent).[13] In the rest of the compared countries the share is approximately 20 percent. (Ibid., 15–18.) Regarding sources of funding,

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12 Belgian data includes, however only sources of Flemish public funding. The inclusion of other sources (e.g., EU) would probably bring Belgium closer to other countries.

government-related sources rank highest in all the other countries except in the UK and the Netherlands, where foundations and charities play a prominent role. For instance, in 1998 in the UK, government-related sources covered approximately 26 percent of third-stream financing while foundations and charities covered 33 percent. Industry's share varies rather significantly country-by-country. In 1997 its share in the sample countries was as follows: Finland 26 percent, Germany 30 percent, the Netherlands 22 percent, Switzerland 40 percent and the UK 17 percent. However, industry's significance as a source of funding has grown in all the sample countries during the 1990s except in the UK, where its share even decreased by a few percents. The significance of EU and other international funding has also grown, but most strikingly in Finland, where EU membership clearly boosted international funding in the mid-1990s. (Ibid., 20.)

In second-stream funding Belgium, ranks highest with about 40 percent of total university research financing. In the UK and Finland the level is approximately between 20 and 25 percent. In the rest of the countries the level has remind below 15 percent. Second stream funding has remained almost stagnant throughout the 1990s, even though there has been a slight increase in its relative importance in every country. (Ibid., 15—18.) All the countries also use directed modes of funding (e.g., thematic priorities, research programs) in their public research finance. Hackmann and Klemperer's data, however do not allow us to draw any conclusions whether priority-setting has increased or declined during the 1990s, even though this kind of tendency has been recognized by other observers (e.g. Skoie 1996).

In this comparison, the overall funding changes in Finland seem rather radical, even though the direction of trends is similar to other countries. The changes between different streams of funding are less striking in the other countries if the UK is excluded. The UK can be considered as a spearhead regarding implementation of radical changes in university funding. An interesting and striking feature in the UK's university funding is, however, that industry's share of third-stream financing is relatively modest. It is also interesting that government has such a strong role as a financier in all the sample countries except in the UK. Obviously, this finding reflects the fact that the tradition of government-supported universities in Europe is still strong and the UK's intentional attempt to diminish radically the role of the government is rather unique. Regarding non-academic collaboration, these statistics seem to suggest that Finland has developed this dimension rapidly during the 1990s in relation to other countries. For instance, it is only in Germany and in Switzerland where financing by industry has a more prominent position in the universities than in Finland. Concerning international finance, Finland, however, is a clear winner. This observation suggests that Finnish universities have been very active in fostering international contacts and taking advantage of EU funding.

The nature of the links

Policy-makers have considered the strengthening of university-industry-government linkages as necessary, but the introduction of the linkages and increasing contract research as a funding basis for university research has also provoked tensions and doubts within the academic community. These tensions can be summed up with the idea that research collaboration with industry is against the ethos of universities as places for fundamental research and the education of students. It is feared that industry cooperation could harm universities and have undesirable side effects on researchers' work. (Howells et al. 1998, 13.)

Even though there is some justification for this fear, the evidence from the interviews in this study shows that the issue is more complicated. As the significance of external funding has grown, externally funded research is currently, more or less, a taken-for-granted situation among researchers. It seems that university basic funding is spent largely on maintaining necessary infrastructure and salary coverage. Cutbacks and an increasing number of students have narrowed the universities' financial elbowroom. Therefore, there is currently almost no finance for substantive research activity. Especially for empirical research, the funding has to be acquired from external 'funding markets'. Overall, it seems that increasing external funding has made it possible to maintain and diversify university research as well as build bridges over basic resource gaps.

What is even more interesting, the researchers claimed that contract research does not necessarily contradict academic aspirations (basic research interests), even though it may create some problems in research organization. Short-term contracts and continuous applying for funding create an environment in which a constant rush and backbreaking workloads shape working conditions. Many interviewees claimed, for instance, that as a result there is not enough time to utilize gathered data for academic publications. The interviewees did not have a sense, however, that financiers would try to excessively steer their work. The deferring of publications due to the secrecy of research results was not a major problem either, even though it happens sometimes. Instead, besides financial benefits, researchers experienced that collaboration may benefit research by opening access to such expertise and knowledge that is embedded in partner organizations.

From the general point of view, these results seem to be rather parallel to other empirical studies that have dealt with university-industry collaboration. For instance, access to funding is usually reported to be one of the main motivations for starting collaboration. There are, however, other reasons. Howells et al. (1998, 9) reported on the basis of a survey and interviews that in the UK "access to research funding is seen as the prime motivating factor by higher education institutions, but only as a means to pursue goals which fulfill the aims of both academic and industrial partners". Thus collaboration with industry was seen also as a strategic institutional policy objective and as a means that provided an exploitation outlet for research capabilities and potential access to complementary expertise. (Ibid., 20.)

Rather similar results can be seen in a Canadian survey of university researchers (Zieminski & Warda 1999); even though its statistical representativeness is more than highly questionable. The presence of collaboration champions, access to industrial expertise, access to government funds, access to private sector financing and changing university culture were ranked as the most critical reasons why universities collaborate with companies.

The above-mentioned studies did not address, however, the question, whether collaboration has caused problems in academic organization. Some evidence of the experienced disadvantages can be found from a survey conducted by Meyer-Krahmer and Schmoch (1998) among German universities in the fields of biotechnology, production technology, microelectronics, software and chemistry (N=433). Also in their results additional funds and knowledge exchange were the two foremost mentioned advantages for industrial collaboration. Of the potential disadvantages, the short-term orientation of research was considered as the major one. Clearly less important but ranking in second position, was the limited industrial basis and in the third position, restrictions on publications. 'Less interesting topics', 'administrative problems' and 'unfair terms of contracts' were considered as less important disadvantages.

In addition, Behrens and Gray (2001) studied 'unintended consequences' of cooperation among US engineering graduate students (N=482). An overall conclusion of their study was that they were not able to find evidence that industry's sponsorship had limited students' academic freedom, which was understood as the freedom to choose methods/questions, the freedom to communicate results, and the freedom to interpret results. They did not find any significant differences among groups of students that were funded by government, industry or the university.

At least these studies seem to corroborate the results of this study. Access to funding is considered to be an important motivation for collaboration, and collaboration does not necessarily lead to diminished academic freedom. There are, however, also problems and especially the short-term orientation of collaborative research, which came out in the German study, seems to point to the same problems as this study. The interviewees in this study, however, unlike in the German survey, did not experience that collaboration as such would have restricted significantly their publishing opportunities – publishing problems follow most likely from the short-term contracts and rush, not from the nature of the contracts. This is, however, a conclusion that concerns only these interviews, a wider survey would probably also bring to light restrictions on publishing.

It should be mentioned that two of the above-mentioned studies dealt only with engineering sciences. Thus, like Behrens and Gray (2001, 194) remind us, wider generalizations to other disciplines might be misleading. Meyer-Krahmer and Schmoch also point out that there are significant differences even within technical research how disciplines are oriented toward basic research, applied research or development (1998, 840). Therefore, it is possible that an interpretation of what is 'basic' or 'applied' research may vary discipline-by-discipline, complicating also the interpretation of the 'academic orientation' of research. While this warning is in order, it is interesting to note, however, how these studies point to the same conclusions as our data.

The landscape of non-academic research cooperation seems rather 'conventional'. Cooperation takes place mostly within frameworks of collaborative contract research and public research programs, while researchers have not established, for instance, 'hybrid research groups' (cf. Gibbons et al. 1994). These modes of operation seem to create also a kind of core to which the focal modes of knowledge transfer are attached. Active communication among partners either in the form of visits, meetings, reporting or seminars lay the basis for knowledge transfer. Thus, project-related informal communication is important for the research partners. Additionally, companies recruit university researchers from projects in order to guarantee knowledge transfer.

The above-mentioned Meyer-Krahmer and Schmoch (1998) survey in the German universities addressed also the question of the forms of collaboration. In descending order according to frequency of 'important' or 'very important' answers, the most important forms of interaction with industry in their study turned out to be: 1. Collaborative research; 2. Informal contacts; 3. Education of personnel, doctoral theses, contract research, conferences and consultancy; 4. Seminars for industry, exchange of scientists, publications; and 5. Committees.

Even though the results of interviews are not as easy to assort in detail as survey results, the overall picture seems to be rather similar. Research collaboration is the most important form of interaction and it also necessitates informal contacts. In fact, it can be claimed that in order to be successful in 'research markets', researchers need a wide variety of contacts – a network in which research information and cooperation possibilities are passed along. Our interpretation is that, ultimately, this means that researchers who are dependent on external research finance are also dependent on networks that typically are 'informal'. Therefore, personal relationships are valuable social capital for researchers as they develop their individual or unit research programs.

An interesting feature of the Meyer-Krahmer and Schmoch survey is also that researchers rank collaborative research higher than contract research. Meyer-Krahmer and Schmoch explain this by interpreting that collaborative research implies bi-directional knowledge exchange, while contract research is primarily a uni-directional knowledge transfer from the universities. The importance of informal contacts seems to support this interpretation and they continue by pointing out that "[o]bviously, industrial researchers have become members of informal networks wherein academic as well as industrial researchers discuss their research projects and findings". (Ibid., 841.)

This is also one of the general conclusions of this study. According to interviews, it can be suggested that there has developed between traditional contract research and academic research an intermediating 'interactive research mode' which can be characterized by qualities like multilateral external contracts, multiple internal and external partners, equal partnership and interactive project design. This mode differs in several dimensions from the two traditional modes of research. This mode is neither exactly similar to Mode 2, propagated by Gibbons et al. (1994), since there still seems to be a distinctive academic focus in research.

The following figure summarizes some of the characteristics of the interactive research mode, traditional contract research, and traditional academic research. The figure depicts also the benefits of research cooperation. Each of three modes of research includes distinctive ways of operating and binding researchers to the research environment. What we have called here traditional contract research can be characterised as being usually based on bi-lateral contracts between financiers and contractors. This kind of relationship contains also (at least potential) hierarchical order, so that contractor is dependent on the financier via finance and research problems that may be predominantly applied by nature.

The interactive project mode differs from traditional contract research in several important ways. From the researcher's perspective, several contracts may relate to one single research program that represents her/his or her/his department's key know-how and research interests (within a department there may be several of these kinds of programs). Even though individual contracts resemble formally traditional contract research, their content is different. A hierarchical power relation is less visible or non-existent. This is reflected, for instance, in the fact that researchers can formulate relatively freely research problems as they assist financiers to find the key problems. The research can be also rather 'academic' in the sense that the financier does not seek immediate development utility but new knowledge, even though the study would be conducted 'in the framework of application' (cf. Gibbons et al. 1994). The knowledge flow is also bi-directional, unlike in traditional contract research. Public research programs that network concurrently several utilizers and conductors of research may also represent this kind of research. It could be said that multifarious interaction is the key to this kind of research.

Traditional academic research can be characterized by a strong reliance on academic sources of finance, like research councils and foundations, by almost totally non-academic actors independent project design, and by interaction that includes almost exclusively academic colleagues.

The three modes characterized here are, naturally, ideal-typical constructions. In reality, for instance, contract research that in all the other features can be characterized as 'traditional' may be based on equal relationships and what we have called here 'pure academic research' may network also non-academic partners. What is also necessary to emphasize is that all the modes of research exist side by side in the current university research landscape, even though the interactive mode would seem to be, according to interviews, replacing the traditional contract research.

Under what conditions has the emergence of an 'interactive research mode' been possible? One answer, which comes directly from the interviews, is that companies have realized that long-term development requires also knowledge

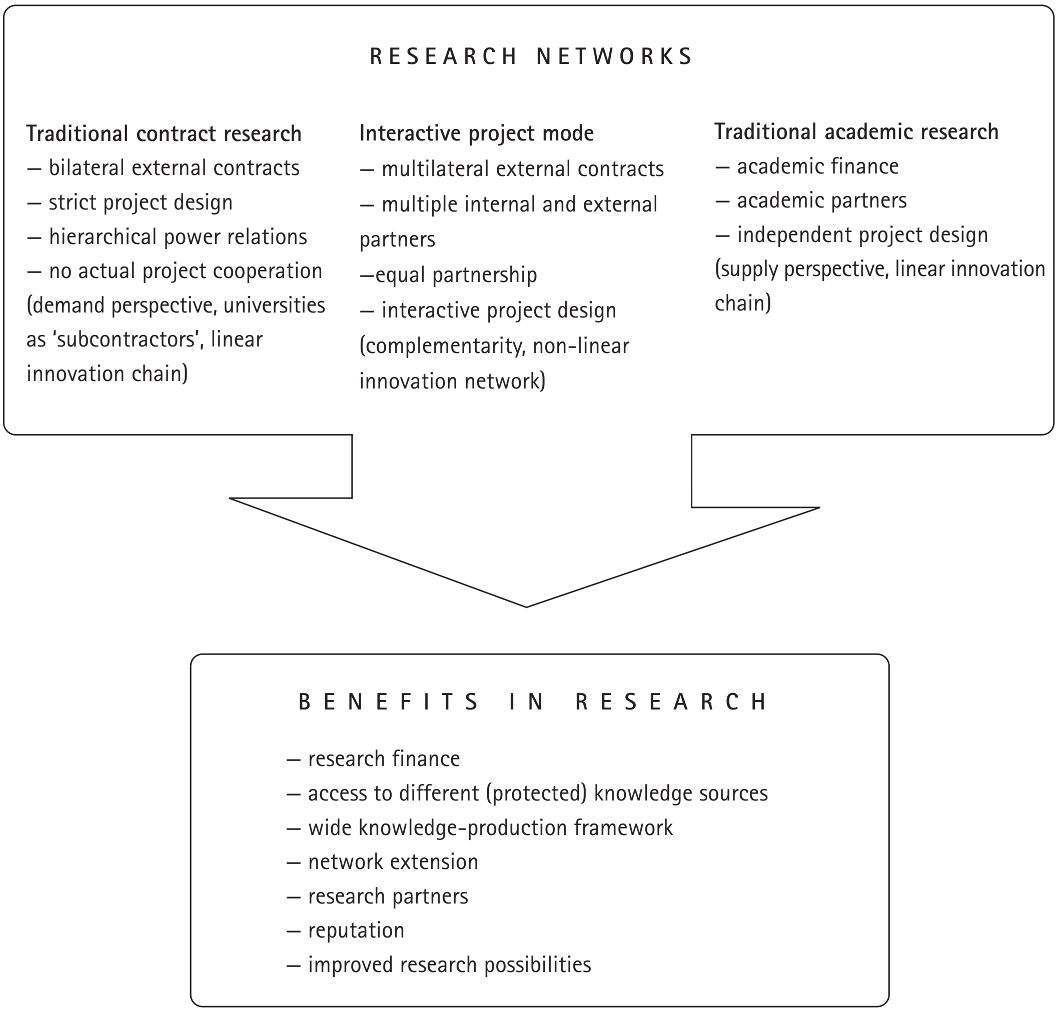

Figure 8. Research networks and their benefits.

production that is not tied directly to applications. This might be possible especially for big, R&D-intensive firms with their own research facilities. Firms' own R&D departments take care of product development, while the role of university research is to produce generic knowledge. As these kinds of firms are also most likely to be in the forefront of technical development, there is no existing 'stock of knowledge' for them to utilize, but the knowledge has to be produced 'here and now'.

An 'interactive research mode' may also be possible due to the fact that university research funding is still predominantly public. Researchers may have a greater degree of freedom in collaboration with industry within the framework of public research programs, as often program aims are in the area of generic knowledge. However, as interviewees reported also that industry or other financiers do not try to steer research excessively in contract research, other explanations are needed. It might be possible, for instance, that the good economic situation is reflected in these relationships. There is more freedom as long as the current economic trend is positive. As it seems to be common that firms are prone to cut their R&D expenditures as soon as the economic situation turns to a negative direction, it is also possible that they would set more precise and development-related goals for contracts.

Each of research modes described above may also create added value for a research enterprise. These advantages may be not only research finance related, but also found in networks of partners, a stronger reputation, and knowledge of the research environment (e.g. funding possibilities, awareness of useful strategies and experience of partners and their views). These can be utilized, in turn, to support the development of research.

Regarding the interactive research mode, it benefits researchers especially if it provides access to such protected or tacit knowledge that would otherwise be difficult to acquire. Cooperation may, for instance, provide up-to-date knowledge concerning the enterprises' technical development. Cooperation creates also, at its best, a wide knowledge-production framework and extended network, in which several researchers and non-academic actors may contribute to research. Knowledge 'flows' in several directions in these relationships and therefore 'knowledge transfer', implying a uni-directional, linear relationship, could be replaced by 'exchange of scientific knowledge', as Meyer-Krahmer and Schmoch have suggested (1998, 842).

The development of interactive relationships, and transformation of the financier-contractor relationship to that of partnership, is not, however, a process without complications. The interviewees often emphasized personal trust and 'chemistry' as a basis for the development of the relationship. Trust as a central prerequisite for functional research collaboration has come out also in other studies. Howells et al. (1998, 9), for instance, have stated, "[m]utual trust and a professional, business-like approach by the academic partners are seen as the keys to success. Keeping linkages over time is dependent upon good personal relationships and avoiding a divergence of objectives during projects".

It can be claimed also that trust is especially important for knowledge flows and exchange of information. Thus one conclusion in a study by Rappert et al. (1999) on university spin-off firms was that "[t]he mobility of knowledge not only depends on the size of the network, but on the characteristics of the networks in which that knowledge is embedded, such as the relations of trust that exist. Given the importance of codified and tacit forms of knowledge, trust is a key element in ensuring the exchange of essential knowledge via linkage" (ibid., 887).

This conclusion seems to fit also the results of this study. As long as trust has not developed, an employer may 'observe' researchers and knowledge flow may be uni-directional, i.e., knowledge transfer occurs from the university to the employer. As trust develops, however, the relationship may develop towards a knowledge exchange between partners. Trust is thus an essential dimension of functional cooperation and multifarious knowledge exchange.

University-industry collaboration

There is a lot of empirical evidence that universities are not usually the primary collaboration partners for companies. For instance, in a recent survey of German manufacturing companies (N=1 800), only one third of the companies had cooperation with universities, while almost two thirds had cooperation with customers and half of the companies cooperated with suppliers (Fritsch & Lukas 1999). In addition, enterprises that collaborate with universities seem usually relatively large and they have in-house R&D departments. In general, the more firms have their own R&D activities, the more they use external knowledge. Thus, external knowledge does not seem to substitute for firms' own knowledge production, but internal and external knowledge production function as complements. (E.g. Fritsch & Lukas 1999; Schibany et al. 1999; Beise & Stahl 1999.)

The findings of our survey are not in contradiction with the evidence from the other countries. For instance, sub-contractors, competitors and non-university research institutes were more important partners in innovation-related cooperation for firms than technical or multi-faculty universities. As companies also usually have a number of partners simultaneously as they collaborate with universities, the result may indicate to the existence of a 'chain-linked model' of innovation processes (Kline & Rosenberg 1986). Because the model stresses information inputs from several sources during the process, cooperation with different types of partners at the same time may reflect the assumptions of chain-linked model (Fritsch & Lukas 2001). Companies utilize several types of knowledge during development processes and universities are but one source of knowledge among others.

Finnish firms cooperating with universities are also usually high- or medium high-tech firms or knowledge-intensive business service companies that have regular in-house R&D activities. Especially in-house R&D activities seem to have great significance for collaboration activity and as a firm's research and development intensity increases, the more likely it is that the firm cooperates with a university. This finding points at, besides the above-mentioned 'complementarity hypothesis', the significance of absorptive capacity (Cohen & Levinthal 1990) as a basis for potential utilization of university research. Firms need to have their own know-how and learning capacity on such a level that they are able to utilize properly external knowledge sources. Surprisingly, however, the data suggests that the turnover of a firm does not have a strong linkage to collaboration. Obviously, the KIBS firms have skewed the results. They collaborate often with universities but their turnover is low. Thus, if KIBS firms are eliminated, the connection is clearer. The differences are clearest in the lowest and highest turnover category, so that in the highest category there are more firms that cooperate with universities than in the lowest category.

In general, other studies have also pointed out that public research has a higher impact on new products than on new processes. In addition, in a German survey (Beise & Stahl 1999, 405) it was found that in non-R&D-intensive industries, 42 percent of the firms utilizing public research in innovation activity developed new processes, while in the R&D-intensive industries, the share was only 29 percent. Our findings gave support to the assumption that collaboration relates usually to product development. The more important the development of products or product quality improvement was for a company, the more likely it had university cooperation. However, there were no big differences between firms according to their technological level or R&D intensity.

The proximity of private and public R&D is usually seen to have a positive effect on knowledge spillovers. Case studies have recognized regional innovation milieus (like Silicon Valley, Route 128) that are seen to foster commercialization of new technologies and knowledge. The explanation for the effects of proximity has been that if research outputs cannot be reduced to formal, codified knowledge, they cannot be transferred over long distances and require face-to-face communication. (Beise & Stahl 1999, 409.)

There is, however, some evidence that questions any straightforward conclusions. For instance, in a survey of major US firms (Mansfield & Lee 1996) in the electronic, information processing, chemical, petroleum, pharmaceutical, instruments and metal industries, it was found that the mean proportion of R&D supported at universities less than 100 miles away was more than double the support for R&D at universities located 100—1 000 miles away and more than triple R&D support at universities more than 1 000 miles away. Mansfield & Lee, however, also found that holding distance constant, the mean proportion of R&D supported at some university with a good-to-distinguished department is higher than at some university with a lower-rated department (measured by NAS ratings). Thus, the universities cited by firms as having contributed most significantly to their development activities tended to be the leading universities like MIT, Berkeley, Stanford, Harvard and Yale. For the other universities, the distance, however, mattered. The explanation for this phenomenon was that the more fundamental the research is, the less distance matters, because less intensive interaction between firm and university personnel is required. Thus, holding quality constant, the amount of applied R&D supported by firms at a particular university less than 100 miles away tended to be at least ten times as great as at a more remote university.

Also Beise and Stahl (1999) found in their survey of German firms that the majority of the universities firms cited as their partners were located inside a 100-km radius from the firms. They, however, put forward serious doubts whether geographical proximity would lead to positive spillover effects. They supported this claim through their survey, finding that those firms that reported public research -supported innovations did not differ from other firms in terms of distances from public research institutions. Their conclusion was that firms tend to name institutions close to them, even though there is no higher probability of receiving spillover knowledge from them. Their interpretation was that firms seeking external knowledge start by checking sources nearby and look for more distant sources only if they fail to find any appropriate knowledge in their own region.

It seems that also the findings of this study could be interpreted along the lines of the above-cited studies. Namely, it seems that regional proximity matters for the Finnish firms. For instance, 74 percent of the companies cooperating with Tampere University of Technology were from the Tampere region and no less than 91 percent of the companies cooperating with University of Oulu were from the Oulu region. Exceptions in this regard were the Turku region companies that were partnering actively also with Helsinki University of Technology and Tampere University of Technology. The reason for this seems rather clear: the companies are seeking predominantly technological knowledge and there is no technical university in the Turku region. Thus, Turku region companies are seeking more distant knowledge sources, as they cannot find appropriate ones in their own region.

An interesting exception is also Helsinki University of Technology, which was cited frequently by companies from all the regions in the sample (Oulu, Tampere, Turku), although it cannot be considered as a regional university for these companies. Even though we do not have any possibility to measure quality across the above-mentioned universities, it is possible that Mansfield and Lee's 'quality argument' is supported by this finding. At least it is possible to think that Helsinki University of Technology as the biggest technical university in Finland may provide research possibilities that are unavailable in the other universities; or that its status as the leading technical university in Finland attracts firms. This conclusion is also supported by answers to the question, why a firm had started cooperation with the university department(s) with which it cooperated. Regional closeness was not the primary reason for starting cooperation, but clearly the majority of respondents considered the applicability of the services, the university's active orientation to cooperation, and high standard of research as focal reasons for the start of cooperation. This finding seems to support the interpretation that firms seeking external knowledge start by checking sources nearby and look for more distant sources only if they fail to find any appropriate knowledge in their own region.

Why do not some firms, then, cooperate with universities? Are there specific barriers to cooperation? In this sample, the companies that had not cooperated with universities considered a lack of time as the most important single barrier. Almost as important was the lack of information of the cooperation possibilities. Approximately three fourths of the respondents in this study considered the lack of information as somehow a significant obstacle. As also altogether 90 percent of the respondents thought that universities should develop their information services, the lack of proper information can be considered as a very significant obstacle for starting cooperation with universities. Not surprisingly, the lack of resources was a significant obstacle for companies with modest turnover. A lack of information as a barrier to cooperation has been identified also in other surveys. For instance, Schibany et al. (1999, 47) reported on the basis of their Austrian survey that the two focal reasons the companies considered as barriers to cooperation were 'academic research is not application-oriented' and 'lack of information on research conducted in universities'. Their conclusion was that "the missing link between the academic and the industrial sector for common research activities is a rather 'simple' one, i.e., the lack of information about the research going on at the universities and not poor equipment or missing interest" (ibid.). While this kind of generalization is too simple due to, for instance, obvious reasons related to absorptive capacity, the finding points to an important problem that needs addressing if university-industry collaboration is to be enhanced.

The problem-solving capacity of universities and access to complementary know-how are often mentioned as the primary benefits of university-industry collaboration for companies. In addition, contributions to the trained work force in the form of graduated students is also recognized as a major economic benefit. (Pavitt 1998; Salter & Martin 2001.) Rappert et al. (1999, 877) found in their interview study that the English companies considered as the major benefits 'networking and keeping abreast of university research', 'access to expertise' and 'general assistance and help with specific problems'. On their part, Schibany et al. (1999, 40) report as results of their Austrian survey that firms benefit from cooperation with universities through four main channels: educated and skilled personnel; access to up-to-date research (new ideas); access to general and useful information; and direct support in the development process. Almost correspondingly the major goals for university cooperation were: increased problem-solving capacity, expected learning processes; access to state-of-the-art science and access to complementary know-how (ibid., 43).

Against this background, it is not very surprising that cooperating companies in this sample considered commercial utilization of knowledge, acquiring new scientific knowledge and monitoring technological development as the most important goals for university cooperation. Correspondingly, the respondents assessed that university cooperation had impacted mostly on the company's know-how. Approximately four fifths of the companies that had cooperation estimated that cooperation had increased the company's know-how to some extent or very much. Compared to this, it is interesting to note that only half of the respondents estimated that cooperation had a fair or big impact on product/service quality. The study of the forms of cooperation indicates also that education-related cooperation in the form of master's thesis projects is very important for the firms. Obviously educational cooperation creates possibilities to screen and recruit future personnel and thus play an important role as a means of recruitment.

As a whole the results of this survey correspond rather well to the findings of earlier studies. The major benefits and goals of cooperation are mainly in the area of generic knowledge, even though more product development-oriented cooperation (commercial utilization of knowledge) is highest as a purpose of cooperation. In spite of this discrepancy, it is evident that firms appreciate also generic knowledge, as the high appreciation of scientific and technical knowledge as a goal of collaboration indicates. The result can be interpreted also as such that there has developed a sort of functional division of labor between universities and companies. Universities are more involved in production of generic knowledge while the major task of firms is to convert that knowledge into applications. This division, however, may depend a lot on the firm's absorptive capacity and in-house R&D. For a firm with large R&D facilities it is easier to utilize generic knowledge than for a firm with limited or non-existent R&D facilities. Naturally, in the latter case the division of labor does not work, but more likely researchers have to go more into applied research and development if the firm is going to benefit from the cooperation.

Companies seem to be, however, rather content with the collaboration in the sense that they have not experienced any major problems or the problems have been minor. Problems have concerned usually communication, the inactivity of some partners, their know-how or supply of funding. Even in these cases, approximately two thirds of the respondents considered that there had not been any problems. What is even more interesting, the confidentiality of research results had been a problem only for one tenth and intellectual property rights for one fifth of the respondents, even though these are areas where contradictions are most likely to occur. The problems formed four rather distinctive groups that related to: communication and know-how; utilization of results; reorganization and change of partners; and too ambitious objectives. There were, however, no remarkable differences among the firms in their responses.

The result is quite different from the results of the only study we were able to locate addressing directly these questions. Schibany et al. (1999, 48) report that Austrian companies experienced rather often problems in several dimensions of cooperation. For instance, from 45 to 55 percent of companies had faced problems with insecure economic value of results, high coordination costs and divergent goals; and from 25 to 35 percent with the underestimation of the workload, divergent time constraints, and intellectual property rights. The least problems were with cultural differences between partners (15 percent of respondents).

The difference in results may partially derive from the fact that the variables were not similar. The differences in variables also complicate comparisons. However, there are some variables that resemble each other and can be compared. For instance, almost 30 percent of Austrian firms had faced problems with intellectual property rights, while in Finland under 20 percent of firms had corresponding problems and for only four percent were these problems major. Correspondingly, the variables 'diverging goals of partners' in the Austrian survey and 'change of partner's objectives' in our survey could be interpreted as having measured approximately the same thing, but Austrian firms experienced more problems than the Finnish ones. The results of the Austrian survey are also difficult to compare to the results of this survey, since Schibany et al. do not report to what degree the respondents experienced the problems as significant. However, keeping these problems in mind, it seems that Finnish companies have fewer problems with the universities than their Austrian counterparts. For example, in Austria 55 percent of the respondents had faced at least some kind of problem, while in Finland the corresponding figure was 37 percent. Thus the result seems to indicate that there are national variations in university-industry collaboration problems.

Research development and policy questions

Even though the preceding empirical discussion included numerous policy-related questions, any easy or ready-made R&D policy conclusions are, as Salter et al. (2001) have emphasized, hard to arrive at due to the increasing complexity of the S&T system. The research system alone, as part of the innovation system, involves a great number of vertical and horizontal linkages between R&D actors and policy-making levels. Also the forms of interaction between various types of research and innovation activities vary according to the field of science, technology and industrial sector, increasing further the diversity of the system.

Thus, monitoring and assessing the benefits of university research on economic development and the society at large is a most complicated task. As indicated earlier, the socio-economic impact of university research involves a wide variety of forms, which are often indirect and difficult to trace. However, there are some research development and policy-related questions which we want to pay some more attention to. They concern both national and institutional, university level issues and activities.

In general, the research activities of Finnish universities expanded considerably during the 1990s and the universities are now research institutions in a much stronger sense than a decade ago. Their research function has grown in significance relative to other university activities and also in comparison to sectoral research institutes. Following the cutbacks in basic budget funding in the early 1990s, this growth in research has been almost exclusively based on competitive funding from external sources.

In order to compensate for the scarcity of basic funding – both for higher education and research – universities have been receptive to accommodate new, more practically oriented tasks to get additional income and to increase their socio-political legitimacy. In this sense, universities have actually become economic actors and increasingly assumed business-like principles in their activities. This trend is further stimulated by the growing expectations and demands universities are now facing from different parts of society. It seems justified to think that universities should be more directly useful and provide various knowledge-intensive services, both paid and unpaid, to surrounding society. But is it reasonable to expect that universities will be able to fulfil all these expectations when taken together? This development, a quest for extra funding together with growing external demands, may lead to a state of functional overload, where universities assume too many different tasks without being able to properly carry them all out.

In our view, there is a problem, both at the national policy level and in the internal university discussions, that the perspectives on university development are typically limited to this or that specific function. Especially this concerns the distinction between higher education and research functions (not to speak of innovation-related services), which is further reinforced by parallel administrative and policy divisions. Therefore, it is important to assume a more comprehensive view of university activities and their functions as a whole in order to realistically evaluate the current state of universities, e.g., the challenges inherent in matching their resources with their tasks and related external expectations.

For the strategic development of universities it is important to discuss and define principles and priorities in developing the whole spectrum of university activities. Alternatively, if maintaining internal synergy is not regarded as an important issue, universities may simply remain an institutional frame or 'umbrella' for hosting old and new, often increasingly diverse activities, without much selectivity. It seems to us that since the 1990s, when Finnish universities first struggled to survive and to preserve their functions and then competed for new research and other additional funding, the latter more pragmatic attitude has prevailed.

As the societal and financial linkages of universities have become more diverse and close, this tends to influence internal activities and their organisation within universities as well. The expansion of university research and its finance from new sources has increased the internal differentiation of research and the diversity of university activities as a whole. During the 1990s, university research functions have become increasingly differentiated from educational activities. A general trend has been to establish separately, and more or less formally, organised research units and centres within universities. The development of new research structures has largely been an 'evolutionary' process based on self-organisation and initiatives from below. (Cf. Nieminen 2000b.)

The restructuring of university research has reflected both new needs and opportunities for research development. The establishment of research units, typically with very few basic resources, has been a flexible way to profile university research towards key areas in basic and applied research while taking into account changing S&T policy priorities. The expansion and increasing complexity of research problems often demand interdisciplinary collaboration and the integration of basic and applied research. Meeting these demands and crossing disciplinary boundaries is more difficult in the traditional teaching departments than in separately organised research units and centres. An indication of this is that research units have in general been more active than departments in acquiring research funding from outside sources and in developing external research collaboration. On the other hand there is a need to counteract excessive differentiation of university activities and to find ways to reintegrate new research functions and graduate education, especially as concerns researcher training.

In order to develop dynamic research groups and broader research environments in today's Finnish universities, it is necessary to be able to acquire, to combine and to balance different kinds of research funding — shorter and longer-term — from various sources. In successful cases the combined funding enables the creation of meaningful research entities and the maintenance of sufficient scope and continuity in the research. On the other hand, there are obvious and typical problems related to project research, such as often back-breaking workloads and rush, the lack of continuity of research programs and regeneration of researchers, combining project work with academic meriting, and maintaining qualified personnel (especially in technical research). To balance these negative effects of short-term funding, it is critical for a research group or unit to also have basic funding to secure more long-term research and senior researcher recruitment.

Thus, while it is obvious that external funding motivates networking, it is also obvious that more basic resources would be needed to maintain the research infrastructure, and to guarantee possibilities for continuous development and accumulation of the knowledge base in research units. A well-functioning and sustainable science base is important both from the perspective of direct and indirect contributions to socio-economic development. In case an increase in direct budget funding for research is not considered appropriate, other possibilities could be provided by competitive or result-based funding schemes for developing the research infrastructure and the science base.

Structural changes in the Finnish research system and university funding have been partly unique and nationally specific, related to the major turns in the economy and policy. On the other hand, Finland has followed the more general trends in European development as indicated by R&D statistics.

According to Keith Pavitt the shift in European funding policies towards placing more demands on the practical relevance of publicly funded basic research has come from "those in governments (and particularly in Ministries of Finance) who are responsible for the accountability and effectiveness of public expenditures, and who cannot (or do not want to) understand the complexities of tracing the benefits of basic research" (Pavitt 2000, 13). In Pavitt's view this policy has been based on misinterpretations of US policy and the causes of its success in turning basic research into commercial success. Pavitt points out that US firms mostly use university research that is performed in high quality research universities, published in quality academic journals, funded publicly, and cited frequently by academics themselves. In addition, the proportion of university research that is business-financed in the US is smaller than in most European countries, and US strength in biomedical and ICT-related fields is based on massive government funding of basic research and related post-graduate education. Pavitt also notes that – against the common view – in European business firms "many of the managers in fact fully understand the benefits of basic research activities complementary to their own applied research and development activities" (ibid., 14).

In recent Finnish policy discussions as well relatively little attention has been paid to the issue of academic 'core' functions and competencies. As we have already argued, the functioning of this knowledge base seems to be very important for the functioning of the whole innovation system; and evidently more attention should be paid to these structures. If more attention is paid to the 'academic core', also the diversity of the research system should be recognized. It seems that there would be a need for a diversified and multi-perspective policy that, at the same time, would take into account the disciplinary specific problems and the internal connections within the system.

This is a challenging task, as the increasing diversity of university activities also tends to bring forth new tensions and hence potential conflicts within the institution. Universities currently accommodate a broadening spectrum of educational, training and research functions, ranging from basic activities to market-oriented services. These activities, to some degree, compete with each other for the same basic resources, but they may also produce internal synergy when properly related and managed. Another challenging task for university leadership at different levels is the organisational development and management of research in such a way that the old disciplinary and faculty structures become more flexible and are able to collaborate with the new multidisciplinary and problem-oriented research units and networks. In the strategic development of universities it is essential also that the research structures would be appropriately represented in university decision-making and administration, the structures of which still largely correspond to the older educational faculty structures. On the other hand, one may ask whether the universities have the actual means and policy tools needed for real strategic development — in a situation in which universities still suffer from a lack of basic and free resources, both in basic education and research.

More generally these problems relate to the question, how to maintain effectiveness and networking in tandem with supporting academic 'core' functions? Obviously there are no easy or clear-cut answers to this question. On a general level it can be claimed that universities should strengthen the layer of research and service units which serve societal needs — throughout the whole disciplinary matrix — and at the same time protect academic core functions. As Burton Clark (1998) has suggested this outer layer would possibly protect academic core functions and benefit them if it is organized properly. It might act as a buffer against excessive societal demands, while its project activity might benefit the academic core in the form of knowledge impacts and surplus finance. In order to function properly, this interface, however, would need university level deliberate policy actions and consensus on its functions. Also, undoubtedly, some reallocation of finance and structural reorganization would be needed.

It is important to note, however, that the definition of academic core functions itself is a relative and historically changing issue. In addition to traditional basic sciences, new scientific and technological fields, often involving multidisciplinary combinations, are continuously emerging and may become strategically important. At the same time, new scientific and related professional competencies are emerging and evolving. This close connection between scientific research and new professional skills and competencies underlines the importance of investing in universities and basic research. In addition, it has become obvious that the free-rider option in research and knowledge transfer is not available for a small country such as Finland. Even basic scientific knowledge is embedded in persons and human competencies, largely as tacit knowledge, which cannot be easily transferred as technical 'information'. This concerns even more research skills and methodologies, problem-solving competencies, and forefront research in the new areas.

What is the position of the humanities and social sciences in this constellation? Quite recently, also in Finnish technology policy discussions, the role of 'soft sciences' in innovation activities and technology programs has been raised. There is no doubt that socio-economic and human aspects are becoming increasingly important from the point of view of technological and industrial development. The soft fields actually deal with hard problems which cannot be solved by hard S&T-based knowledge only. Major issues include: the human interface of technological development; socio-economic problems related to the aging information society; policy problems and the citizens' perspective on societal development. In dealing with such issues as the future of cities and work it is evident that technological innovations alone do not suffice; social studies and innovations are needed as well. The integration of soft and hard approaches can be promoted in different ways and in different institutional settings (e.g. in national and international research programs). Assuming a broader perspective on technological and societal development may re-emphasize the importance of academic science, as it still constitutes the most versatile research base and is the main producer of soft scientific knowledge and manpower.

To conclude, we suggest a broad and balanced conception of R&D and innovation policy that acknowledges the different functions, competencies and the relative independence of the main institutional partners. Accordingly, institutional integration in the research and innovation system should be based on complementarity and a functional division of labor rather than on eliminating the institutional differences and squeezing the research activities into one single mode. For instance universities have to maintain multiple research and educational functions if they want to serve the whole society. To be able to do this, universities need to preserve and develop further their core competencies and to act more as partners than as subcontractors. It is also essential to allow for a considerable degree of pluralism and diversity in the R&D system, especially as concerns more basic research oriented activities. There is thus a need for ST&I policy, both at the university and national levels, that would take into account more explicitly differences among research fields, modes of research, universities and their utilisation potential.

Suomenkielinen tiivistelmä

YLIOPISTOT JA TUTKIMUSVERKOSTOT TIETOTALOUDESSA

Silmäys suomalaiseen kehitykseen

Johdanto

Tiedon (tai informaation) mieltäminen keskeiseksi taloudelliseksi kilpailukykytekijäksi on viime vuosikymmenien aikana korostanut myös julkisten tutkimusorganisaatioiden taloudellista merkitystä. Samalla tutkimus- ja kehittämistoimintaan kohdistetut odotukset ovat kasvaneet. Tiede- ja tutkimusorganisaatioiden tehtäväksi on nähty perinteisen tutkimustoiminnan lisäksi teknis-taloudellisesti relevantin tiedon tuottaminen sekä sen tehokas siirtäminen teollisuuden ja muiden tiedon käyttäjien hyödynnettäväksi. Poliittiset päätöksentekijät ovatkin kohdanneet näissä kysymyksissä jatkuvan haasteen. Yhtäältä on ollut välttämätöntä pohtia, minkälainen on yhteiskunnan kannalta mahdollisimman tehokas, vaikuttava ja uusiutumiskykyinen tutkimusjärjestelmä. Toisaalta samanaikaisesti on ollut kehitettävä sellaisia rahoitusmekanismeja ja politiikkainstrumentteja, joilla järjestelmää on voitu ohjata haluttuun suuntaan.

Toimintaympäristön muutos on aiheuttanut myös yliopistoissa moninaisia rakenteellisia ja toiminnallisia kehittämispaineita. Yliopistot ovat pyrkineet takaamaan rahoituksen jatkuvuuden ja vastaamaan yhteiskunnallisiin odotuksiin uudelleenorganisoimalla ja lisäämällä tutkimus- ja koulutuspalveluitaan. Yliopistojen yhteyteen tai läheisyyteen perustetut tiede- ja teknologiakeskukset, yliopistojen omat tutkimuspalveluorganisaatiot ja -yksiköt sekä täydennyskoulutustarjonnan lisääntyminen ovat esimerkkejä tästä kehityksestä.

Samalla on herännyt myös huoli siitä, että yliopistollisesta tutkimuksesta on tulossa luonteeltaan entistä soveltavampaa, rajattuihin ongelmiin suuntautunutta ja tieteen ulkopuolisista laatukriteereistä ohjautuvaa. Onkin kärjistetysti esitetty, että kun omistusoikeus tietoon, patentointi ja taloudellinen hyödyntäminen ovat nousseet keskeisiksi kysymyksiksi myös julkisen tutkimuksen alueelle, tiedon 'julkisena hyödykkeenä' on paljolti korvannut tieto 'markkinatavarana'. Tämä on puolestaan herättänyt kysymyksiä muun muassa siitä, voiko tieteen julkinen ja itseään korjaava prosessi toteutua, jos tieteellisestä tiedosta tulee yhä laajemmin omistusoikeuksin suojattua ja täten ei-julkista.

On myös esitetty arvioita, että julkisesti rahoitettujen tutkimusorganisaatioiden merkitys innovaatioiden kehittämisessä olisi luultua vähäisempi. Keskeisellä sijalla olisi sen sijaan yritysten oma tutkimus- ja kehittämistoiminta. Koska teolliset innovaatiot ovat vain harvoin luonteeltaan radikaaleja, väittämä on perusteltu, jos tarkastellaan teollisuuden omaa innovaatiotoimintaa ja julkisen tutkimuksen välitöntä roolia siinä. Väittämä voidaan myös kyseenalaistaa. Yhtäältä julkisesti rahoitettu tutkimus tuottaa jatkuvasti uusiutuvan tietovarannon, jota yritykset voivat halutessaan hyödyntää. Toisaalta, jos tarvittavaa tietoa ei ole olemassa, yliopistojen tutkimuspanosta tarvitaan tuon tiedon tuottamiseen etenkin jos se on riskialttiiksi mielletyn perustutkimuksen alueella. Vain harvoilla yrityksillä on resursseja omaehtoisen tutkimuskapasiteetin ja infrastruktuurin rakentamiseksi. Kokonaisyhteiskunnallisen hyödyn kannalta yrityksillä onkin taipumus ali-investoida tutkimustoimintaan. Lisäksi on huomautettu, että etenkään teollisen ja teknologisen kehityksen kärkimaissa ei ole mahdollista pitäytyä ulkomailta tapahtuvan teknologian ja tiedon siirron varassa mikäli kilpailukyky aiotaan säilyttää. Vaikka esimerkiksi Suomen kannalta suuri osa eturintaman teknologisesta tiedosta tuotetaan ulkomailla, tiedon siirto edellyttää vastavuoroisuutta ja osallistumista sen tuottamiseen. Toisaalta se, miten tietoa voidaan hyödyntää kansallisesti riippuu maan omasta tiedollisesta ja tutkimuksellisesta kapasiteetista.

Yksityiskohtaisemmissa erittelyissä keskeisiksi julkisesti rahoitetun tutkimuksen taloudellisiksi hyödyiksi on esitetty hyödyllisen tiedon varannon luomista, koulutusta, tieteellisten instrumenttien ja metodologioiden kehittämistä, verkostojen muodostamista ja vuorovaikutuksen stimuloimista, tieteellisten ja teknologisten ongelmien ratkaisupotentiaalin lisäämistä sekä uusien tieto-intensiivisten yritysten perustamista. Nämä hyödyt puolestaan vaihtelevat teollisuuden- ja tieteenalojen mukaan: esimerkiksi nopeasti kehittyvät biotekniikka- ja tietoliikennesektorit tukeutuvat vahvasti julkiseen tutkimusjärjestelmään kun taas esimerkiksi perinteisen metalliteollisuuden tutkimus- ja kehittämistoiminnan (t&k) investoinnit ovat olleet näitä aloja vaatimattomampia. Yliopistollisella tutkimuksella on yhteiskunnassa myös laajempi rooli kuin teollisten innovaatioiden tukeminen: tietomme yhteiskunnasta, sen osajärjestelmistä, kulttuurista jne. perustuvat pitkälti julkiseen tutkimukseen.

Tutkimuksen ja sen hyödyntämisen välisiä suhteita tarkasteleva tutkimus on yleensä painottanut teknologian siirtoon ja hyödyntämiseen liittyviä kysymyksiä. Tästä poiketen tässä tutkimuksessa lähtökohtana ovat olleet tutkimusjärjestelmään ja erityisesti yliopistolliseen tutkimukseen liittyvät kysymykset. Uuden tiedon tuotanto ja sen ehdot ovat nähdäksemme toimivan innovaatiojärjestelmän kannalta yhtä merkittäviä kuin tiedon siirto ja hyödyntäminen.

Yliopistollisen tutkimuksen suhde tiedon hyödyntäjiin on kompleksinen ja monitasoinen ongelma. Kysymystä lähestytään tutkimusjärjestelmän näkökulmasta sillä heuristisella olettamuksella, että suhteet muotoutuvat kolmella perustasolla: instituutio- ja toimijapohjaisella ulottuvuudella, tieteen- ja tutkimuksen tiedollisella tai substantiaalisella ulottuvuudella sekä alueellisella ulottuvuudella paikallisesta globaaliin. Eri alojen tutkimusintressit samoin kuin mahdollisuudet tutkimuksen hyödyntämiseen vaihtelevat näiden perustasojen ja niihin kytkeytyvien suhdeverkostojen kokonaisuudessa. Tutkimus painottuu kuitenkin kansallisen yhteistyön tarkasteluun institutionaalisella ulottuvuudella.

Monipuolisen kuvan luomiseksi tutkimusyhteistyön ja -ympäristöjen muutoksesta tutkimuksessa on hyödynnetty useita erilaisia aineistoja kansallisen tason politiikka- ja tutkimusrahoitusaineistoista tutkijoiden haastatteluihin. Näin syntynyttä kuvaa on täydennetty yrityksissä toteutetulla postikyselyllä, joka edustaa tutkimuksen käyttäjien näkökulmaa. Pääpaino tutkimusyhteistyötä tarkasteltaessa on annettu 'ei-akateemiselle' yhteistyölle. Tällä tarkoitetaan yhteistyötä muiden kuin yliopistollisten partnereiden kanssa – käsitteellä ei siis viitata tutkimustyön sisällölliseen luonteeseen, vaan tutkimuspartnereihin, jotka toimivat yliopistojen ulkopuolella (yritykset, ministeriöt, kansalaisjärjestöt jne.). Tarkastelu etenee makrotasolta mikrotasolle seuraavien kysymyksenasetteluiden kautta:

– Miten tutkimusjärjestelmä ja -politiikka ovat muuttunut 1990-luvulla?
– Minkälaisia vaikutuksia näillä muutoksilla on ollut tutkimusrahoitukseen keskeisenä järjestelmää ohjaavana tekijänä?
– Miten rahoitusvirrat heijastavat tutkimusyhteistyötä ja järjestelmän sisäisiä kytkentöjä?
– Miten tutkijat kokevat ja näkevät ei-akateemisen tutkimusyhteistyön?
– Miten yritykset keskeisenä innovaatiojärjestelmän toimijana näkevät yritysten ja yliopistojen välisen yhteistyön?

Tutkimusjärjestelmän ja -rahoituksen muutos

Viime vuosikymmenten aikana suomalaisessa tiede- ja teknologiajärjestelmässä on tapahtunut useita merkittäviä muutoksia. Voidaan väittää, että muutosten seurauksena järjestelmä on tullut institutionaalisesti entistä monimuotoisemmaksi ja poliittisesti integroituneemmaksi. Esimerkiksi Teknologian kehittämiskeskuksen (Tekes) perustaminen 1980-luvulla ja sen jatkuva kehittyminen loi uusia institutionaalisia puitteita teknilliselle tutkimukselle. Niin ikään EU:n tutkimus- ja kehittämispolitiikka lisäsi 90-luvulla järjestelmään vahvistuvan kansainvälisen ulottuvuuden ja paikalliset ja alueelliset tutkimus- ja kehittämistoiminnan aloitteet (esim.

tiede- ja teknologiakeskukset, osaamiskeskusohjelmat) puolestaan vahvistivat alueellista ulottuvuutta. Järjestelmä monimuotoistui. Samanaikaisesti tiede- ja teknologiapolitiikka lähenivät toisiaan ja kytkennät teollisuus- ja koulutuspolitiikkaan lisääntyivät. Kansallisen innovaatiojärjestelmän käsite toi mukanaan uuden näkemyksen, jonka valossa tiede ja teknologia, tiedon tuotanto ja sen hyödyntäminen ja tätä tukevat infrastruktuurit ja politiikat ymmärrettiin kokonaisvaltaiseksi vuorovaikutusjärjestelmäksi. Tämä edellytti myös lisääntyvää yhteistyötä tutkimuksen rahoituksesta vastaavien ministeriöiden ja rahoitusorganisaatioiden välillä. Poliittisella tasolla tapahtui eri politiikkojen ja toimijoiden lähentymistä.

Samalla kun yliopistojen, tutkimuslaitosten ja teollisuuden yhteistyö nousi keskeiseksi poliittiseksi tavoitteeksi, kilpailua korostavat rahoitusmekanismit saivat kasvavaa huomiota. Rahoituksessa siirryttiin aiemman panoskeskeisyyden sijaan korostamaan tehokkuutta ja vaikuttavuutta. Ulkopuolisen rahoituksen määrä yliopistoissa lisääntyi 1990-luvulla sekä absoluuttisesti että suhteellisesti yliopistoon tai tieteenalaan katsomatta. Tämä johtui lähinnä kahdesta seikasta. Yhtäältä 90-luvun alussa toteutettujen määrärahaleikkausten jälkeen budjettirahoituksen kasvu jäi varsin maltilliseksi vaikka yliopistojen tehtäväkenttä ja opiskelijamäärä kasvoi merkittävästi. Toisaalta tarjolla olleen ulkopuolisen tutkimusrahoituksen määrä kasvoi lähes räjähdysmäisesti. Kun budjettirahoitteisen tutkimuksen laskennallinen lisäys jäi jotakuinkin olemattomaksi, tutkimusta vietiin eteenpäin ja tutkijoita palkattiin lähinnä ulkopuolisella rahoituksella.

Mikäli tutkimusrahoituksen oletetaan heijastavan tutkimusyhteistyötä ja -kontakteja, rahoituslähteiden analyysi osoittaa, että kaikki yliopistot ja tieteenalat tekivät 90-luvun lopulla enemmän yhteistyötä ei-akateemisten kumppanien kanssa kuin 90-luvun alkupuolella (yliopistotutkijoiden ja ei-akateemisten partnereiden välillä on luonnollisesti myös paljon muuta yhteydenpitoa, joka ei 'kirjaudu' rahoitustilastoihin). Tähän vaikuttivat budjettirahoituksen hiipuminen, julkisen rahoituksen uudenlainen suuntaaminen sekä yritysten, ministeriöiden ja EU:n tutkimusrahoituksen lisääntyminen yliopistoissa. Esimerkiksi julkisesti rahoitetut tutkimus- ja teknologiaohjelmat sekä uudet klusteriohjelmat loivat puitteita, joissa yhteistyötä harjoitettiin ja ehkä stimuloivat laajemminkin yhteistyötä. EU:n tutkimusohjelmat lisäsivät puolestaan sekä akateemista että ei-akateemista yhteistyötä kansainvälisellä ulottuvuudella.

Tilanne vaihtelee kuitenkin sekä yliopistoittain että tieteenaloittain. Yliopistoista eniten ulkopuolista tutkimusrahoitusta on teknillisillä korkeakouluilla sekä yliopistoilla, joiden toiminnassa painottuvat tekniikka, luonnontieteet ja/tai lääketi0eteet. Näin ollen ei ole kovinkaan yllättävää, että tieteenalojen keskinäisessä vertailussa muualta kuin Suomen Akatemiasta tai säätiöistä peräisin olevaa ulkopuolista rahoitusta on eniten tekniikassa, lääketieteessä sekä maatalous- ja metsätieteissä. Vaikka luonnontieteiden ulkopuolisesta rahoituksesta yli kolmasosa tulee Suomen Akatemialta, Tekesin ja yritysten suora rahoitus muodostaa vastaavasti kolmasosan rahoituksesta. Eniten yritysrahoitusta on tekniikan ja lääketieteen aloilla; noin viidesosa ulkopuolisesta rahoituksesta on peräisin yrityksiltä. On myös huomattava, että yritysten ja Tekesin rahoitus tavallaan täydentävät toisiaan: kysymys on kummassakin tapauksessa pääosin teknologiseen kehitykseen suunnatusta rahoituksesta, jonka puitteissa tehdään yhteistyötä yritysten kanssa. Ministeriöiden asema yhteiskuntatieteiden tutkimusrahoituksessa on puolestaan merkittävä. Humanistiset tieteet nojautuvat tieteenaloista selkeimmin perinteisiin akateemisiin rahoituslähteisiin, Suomen Akatemiaan ja rahastoihin, jotka kattavat peräti kaksi kolmasosaa näiden tieteenalojen ulkopuolisesta rahoituksesta.

Ulkopuolisen rahoituksen lisäystä tarkasteltaessa on kuitenkin hyvä muistaa, että se on ollut pääosin julkista rahoitusta. Lisäksi on todettava, että vaikka julkista rahoitusta on suunnattu vahvasti teknologian ja innovaatioiden kehittämiseen, samalla myös perustutkimusrahoitus on lisääntynyt. Niin ikään teknologiseen tutkimukseen suunnattu rahoitus on usein luonteeltaan lähellä perinteistä perustutkimusrahoitusta.

Erot tutkimusrahoituksessa heijastavat eroja tutkimuksen sisällöissä, suuntautumisessa ja tieteenalakulttuureissa. Innovaatiojärjestelmään liittyvissä keskusteluissa unohdetaan usein, että yliopistojärjestelmän rakenteet ja tavoitteet eivät kaikilta osin vastaa laajemmin ymmärretyn innovaatiojärjestelmän (teollisen kehittämisen ja markkinoiden) rakenteita ja tavoitteita. Teollisuuden tutkimus- ja kehittämistoiminnan painotuksista johtuen tekniset tieteet, luonnontieteet ja lääketiede tulevat kaikkein lähimmäksi innovaatiojärjestelmän rakenteita. Näillä alueilla yliopistoihin on muodostunut myös varsin vahva välittäjäorganisaatioiden kerrostuma, jolla voidaan ymmärtää ulkopuolisella rahoituksella toimivia tutkimusyksiköitä, tiede- ja teknologiakeskuksia ja palveluyksiköitä, jotka tukevat tiedon siirtoa ja hyödyntämistä yliopistojen ulkopuolella. Toisaalta myös yhteiskuntatieteissä ja jopa humanistisissa tieteissä on löydettävissä esimerkkejä uudenlaisista kytkennöistä yritysmaailmaan ja teolliseen kehittämiseen, joskin nämä tieteenalat ovat selvästi kauempana teknis-taloudelliseen kehitykseen vahvasti kytkettyjen tieteenalojen muodostamasta ytimestä. Tieteenalat saavatkin yhteiskunnan alajärjestelmien toiminnassa toisistaan poikkeavia painotuksia. Sisällölliset painotukset määrittävät niiden asemaa ja merkitystä suhteessa erilaisiin yhteiskunnallisiin tiedollisiin intresseihin ja samalla kytkevät ne toisistaan poikkeaviin toimintakenttiin (esim. tekniikka, talous, politiikka, kansalaisyhteiskunta), joiden mahdollisuudet rahoittaa tutkimusta myös vaihtelevat.

Kuuden Euroopan maan yliopistorahoituksen vertailussa Suomessa 1990-luvulla toteutuneet rahoitusrakenteen muutokset näyttävät varsin merkittäviltä. Rahoitustilastojen tarkastelu osoittaa suomalaisten yliopistojen kehittäneen nopeassa tahdissa ei-akateemista yhteistyötä suhteessa vertailumaihin. Esimerkiksi vain Saksassa ja Sveitsissä teollisuuden rahoittaman yliopistotutkimuksen osuus on merkittävämpi kuin Suomessa. Niin ikään kansainvälisen rahoituksen ja erityisesti EU rahoituksen hankkimisessa suomalaiset yliopistot ovat olleet selkeästi muiden maiden yliopistoja aktiivisempia.

Tutkimusta ulkopuolisella rahoituksella

Tutkijat pitävät ulkopuolisella rahoituksella harjoitettua tutkimusta varsin itsestään selvänä asiantilana. Yliopistojen omista budjeteista ei ole juurikaan löydettävissä rahoitusta etenkään empiiriseen tutkimukseen, joten rahoitus on hankittava ulkopuolisilta rahoitusmarkkinoilta. Kaiken kaikkiaan ulkopuolinen rahoitus on mahdollistanut tutkimuksen kehittämisen budjettirahoituksen ollessa niukkaa.

Hieman yllättävää on, että sopimustutkimus ei haastateltujen tutkijoiden mukaan yleensä ole ristiriidassa perustutkimustavoitteiden kanssa. Perus- ja soveltavan tutkimuksen rajojen etsiminen ei myöskään ole hedelmällistä, koska projektit sisältävät usein elementtejä ja mahdollisuuksia erilaisten tutkimuksellisten tavoitteiden saavuttamiseen. Haastatellut selittivät tätä muun muassa sillä, että esimerkiksi yritykset eivät enää pyri sopimustutkimusten avulla yksinomaan hakemaan ratkaisuja tarkasti rajattuihin sovellusongelmiin, vaan pyrkimyksenä on laajempialainen teknologian kehittäminen. Samansuuntaisen vastauksen sai haastatteluissa niin teknisellä, luonnontieteellisellä kuin yhteiskuntatieteelliselläkin tutkimusalueella toimivilta tutkijoilta. Sopimustutkimus on usein luonteeltaan 'soveltavaa perustutkimusta' –tutkitaan tieteellisesti kiinnostavia ilmiöitä, joilla on myös sovellusarvoa. Osaltaan kokonaistilanteeseen saattaa vaikuttaa se, että merkittävä osa ulkopuolisesta rahoituksesta on peräisin julkisista rahoituslähteistä. Haastatteluista kävi myös ilmi, että etenkään vakiintuneen aseman tutkimuskentässään saavuttaneet yksiköt eivät mielellään lähde mukaan ulkopuolelta määritettyihin puhtaasti soveltaviin hankkeisiin: hankkeet muotoillaan useimmiten partnereiden välisessä dialogissa. On kuitenkin huomautettava, että vaikka sopimustutkimuksen luonteessa saattaa olla tapahtumassa muutos, yliopistoissa toteutetaan edelleen myös hankkeita, joiden päämäärät ovat varsin soveltavia. Miten nämä hankkeet kyetään kytkemään laajempiin tutkimustavoitteisiin vaihtelee puolestaan yksiköittäin.

Projekteille perustuva toiminta tuottaa myös ongelmia tutkimusorganisaatiossa. Suhteellisen lyhytkestoiset sopimukset ja tästä johtuva jatkuva rahoituksen etsiminen tuottaa tutkimusympäristön, jossa kiire ja kohtuuttomat työtaakat määrittävät työskentelyolosuhteita. Akateeminen meritoituminen ja artikkeleiden kirjoittaminen ei ole myöskään helposti yhdistettävissä kiireen sävyttämään projektityöskentelyyn. Monet haastatellut kaipasivatkin perusrahoituksen lisäystä, joka mahdollistaisi sekä tutkijoiden tieteellisen uusiutumisen että esimerkiksi laajempien yhteenvetojen tuottamisen kerätystä materiaalista.

Tutkimusyhteistyötä harjoitetaan pääosin sopimustutkimuksen sekä tutkimus- ja teknologiaohjelmien puitteissa; esimerkiksi konsultoinnilla on vain vähäinen merkitys. Epämuodollisemmalla tasolla tapaamiset, keskustelut jne. täydentävät muodollista yhteistyötä. Tiedon siirto tapahtuu myös pääasiallisesti näissä puitteissa. Projekteihin liittyvät vierailut, kokoukset, seminaarit ja aktiivinen yhteydenpito koetaan luonteviksi tiedon siirron muodoiksi. Yritykset myös palkkaavat työntekijöitä tutkimusprojekteista taatakseen 'hiljaisen tiedon' siirtymisen. Rekrytoinnilla on kuitenkin kahdet kasvot. Etenkin teknologisessa tutkimuksessa tutkimusryhmien ylläpitäminen saattaa olla vaikeata, koska nuoria tutkijoita rekrytoidaan jatkuvasti yrityssektorille.

Ollakseen menestyksekkäitä tutkimusmarkkinoilla tutkijat tarvitsevat laajan joukon kontakteja – verkoston, jossa välitetään sekä tutkimus- että hankeinformaatiota. Kärjistetysti tämä tarkoittaa sitä, että tutkijat, jotka ovat riippuvaisia ulkopuolisesta tutkimusrahoituksesta, ovat myös riippuvaisia partnereiden ja rahoittajien muodostamista verkostoista. Koska yhteistyö on henkilöiden välistä vuorovaikutusta, henkilökohtaisista suhteista tulee osa tutkijoiden keskeistä sosiaalista pääomaa ulkopuolisella rahoituksella toteutetussa projektitutkimuksessa. Haastatteluiden perusteella voidaan esittää, että traditionaalisen sopimustutkimuksen ja riippumattoman akateemisen tutkimuksen väliin on muodostunut interaktiivisen tutkimustyön malli, jota voidaan luonnehtia määreillä ulkopuolisesti rahoitettu, multilateraalisiin tutkimussopimuksiin perustuva, lukuisia akateemisia ja ei-akateemisia partnereita verkottava, vuorovaikutteiseen projektisuunnitteluun perustuva ja vastavuoroiseen kumppanuuteen tukeutuva. Tämä malli eroaa useassa suhteessa perinteisestä akateeminen tutkimus – sopimustutkimus vastakkainasettelusta. Voidaan puhua hybridistä, joka yhdistää ääripäiden eri piirteitä verkostomaiseen tutkimustyöskentelyyn. Akateemiset ja ei-akateemiset verkostot muodostavat kokonaisuuden, jossa perinteiset erot hämärtyvät. Partnereiden keskinäisellä luottamuksella on näissä suhteissa myös keskeinen merkitys. Luottamus mahdollistaa mm. avoimen tiedon vaihdon.

Verkostoituminen hyödyttääkin monin tavoin tutkimusta. Tutkimuspartnerit ja rahoittajat löytyvät verkostoista, ne toimivat markkinointikanavana, välittävät tietoa tutkimussubstanssista ja rahoitusmahdollisuuksista sekä kokemuksia erilaisista partnereista. Toisinaan tutkijat kykenevät luomaan joihinkin partnereihinsa niin pitkäkestoisen ja luottamuksellisen suhteen, että nämä antavat tutkijoiden tarvittaessa käyttää omia laboratorioitaan ja testausvälineistöään korvauksetta. Verkostojen hyödyt eivät kuitenkaan kytkeydy yksinomaan rahaan. Yhteistyössä välittyy tutkijoille esimerkiksi partnereiden teknistä ja organisatorista tietoa.

Haastateltujen, aktiivisesti ei-akateemista yhteistyötä tekevien, tutkijoiden mukaan tutkimusyhteistyössä ei yleensä ole mainittavia ongelmia. Haastatellut eivät esimerkiksi kokeneet, että rahoittajat pyrkisivät ohjaamaan liian paljon tutkimusta haluamaansa suuntaan tai että yritykset olisivat halunneet merkittävästi määritellä tutkimustuloksia salaisiksi. Tutkimustulosten julkaisemiselle on yleensä löydettävissä muotoja, jotka tyydyttävät sekä akateemisia että yritysten intressejä. Niin ikään, vaikka vähäiset kommunikaatioon ja kulttuurieroihin liittyvät ongelmat ovat tutkimusyhteistyössä jokapäiväisiä, niitä ei koeta merkittäviksi.

Immateriaalioikeuksiin liittyy kuitenkin joitakin ongelmalliseksi koettuja näkökohtia. Esimerkiksi laitoksilla, joissa kokemukset tutkijoiden omista patenteista ovat vähäisiä, tutkijat saattavat kokea itsensä epävarmoiksi tilanteessa, joka on heille uusi ja josta on myöskin rajoitetusti tietoa saatavilla. Lisää hämmennystä saattaa aiheuttaa se, että yliopistolla ei ole selkeitä ohjeita ja määräyksiä siitä, miten tutkimustuloksen tai keksinnön kaupallistamisessa olisi edettävä: tässä suhteessa yliopistojen välillä saattaa olla huomattaviakin eroja.

Haastatteluiden antama kuva vastaa kohtuullisesti tuloksia, joita on saatu aiemmissa eri maissa toteutetuissa empiirisissä tutkimuksissa. Esimerkiksi erääksi keskeisimmäksi motiiviksi ei-akateemisen yhteistyön aloittamiselle on todettu lisärahoituksen hankinta. Yhteistyö ei myöskään ole välttämättä vaarantanut akateemista vapautta määritellä tutkimusongelmia ja julkaista tuloksia; koetut ongelmat ovat liittyneet pikemminkin sopimusten lyhytkestoisuuteen. Vastaavasti myös suhteiden vastavuoroisuuden ja tiedonsiirron on nähty perustuvan keskeisesti partnereiden väliseen luottamukseen.

Yliopistot yritysten näkökulmasta

Kuten monissa aiemmissa tutkimuksissa on havaittu, yliopistot ovat yrityksille vain yksi partneri monien muiden joukossa.Yrityskyselyn perusteella esimerkiksi asiakasyritykset, alihankkijat, ei-yliopistolliset tutkimuslaitokset ja jopa kilpailijat ovat monissa tapauksissa yrityksille tärkeämpiä kumppaneita innovaatioihin liittyvässä yhteistyössä kuin tekniset korkeakoulut tai yliopistot.

Yliopistojen ja korkeakoulujen kanssa yhteistyötä tekevät suomalaiset yritykset ovat useimmiten korkean tai keskikorkean teknologian yrityksiä tai tietointensiivisiä palveluyrityksiä, joilla on omaa tutkimus- ja kehitystoimintaa (t&k). Erityisesti yritysten omalla t&k-toiminnalla näyttää olevan keskeinen merkitys aktiiviselle yliopistoyhteistyölle. Nämä havainnot liittyvät todennäköisesti kolmeen seikkaan: ensinnäkin yritysten innovaatiotoiminta on usein vähittäistä tuoteparantelua, jossa yliopistollisen tutkimuksen rooli on vähäinen. Toiseksi yrityksen käytettävissä olevat resurssit määrittävät mahdollisuuksia omiin t&k-investointeihin ja kolmanneksi yritysten kyky hyödyntää tutkimustietoa on sidoksissa niiden omaan tietotaitokapasiteettiin eli niiden absorbatiivinen kapasiteetti vaihtelee.

Keskeisimmiksi syiksi sille, ettei yliopistoyhteistyötä ole aloitettu, yritykset itse mainitsevat kuitenkin ajan ja yhteistyömahdollisuuksia koskevan tiedon puutteen. Noin kolme neljäsosaa vastanneista yhteistyötä tekemättömistä yrityksistä piti tiedon puutetta jollakin tavoin merkittävänä tekijänä. Kun samanaikaisesti peräti 90 prosenttia kaikista vastanneista katsoi, että yliopistojen tulisi parantaa tiedotustaan ja informaatiopalveluitaan, yhteistyömahdollisuuksia koskevaa tiedon puutetta voidaan pitää merkittävänä esteenä yritysten ja yliopistojen yhteistyön laajenemiselle. On kuitenkin syytä huomauttaa, että pelkästään informaation lisääminen tuskin lisää verkostoitumista. Yhteistyösuhteen rakentuminen on kompleksinen prosessi, jossa partnereiden on löydettävä yhteinen intressi, luottamus ja hyöty — kysymys on vastavuoroisesta aktiivisesta prosessista, jossa vastuuta ei voi sälyttää jommallekummalle osapuolelle. Ongelmana ovat myös yritysten erilaiset kompetenssit. Esimerkiksi puhtaasti käytännön kautta osaamistaan rakentaneella pk-yrityksellä lähtökohdat yliopistoyhteistyön aloittamiselle ovat huomattavasti vaikeammat kuin omaa t&k-toimintaa harjoittavalla yrityksellä.

Yritykset tekevät myös usein yhteistyötä yliopistojen kanssa, jotka sijaitsevat niiden läheisyydessä. Tulokset osoittavat kuitenkin, että yritykset etsivät ensisijaisesti laadukasta, yrityksen tarpeita vastaavaa, tutkimusta. Mikäli tätä ei ole löydettävissä siltä alueelta, jossa yritys toimii, se etsii yhteistyökumppaneita kauempaa. Näin ollen, vaikka yliopiston läheisyys on merkitsevä tekijä, se on suhteessa yrityksen tiedon tarpeisiin ja aktiivisuuteen.

Yhteistyötä harjoittaneille yrityksille keskeisimmät yhteistyötavoitteet liittyvät tiedon kaupalliseen hyödyntämiseen, tieteellisen tiedon hankintaan ja teknisen kehityksen seurantaan. Keskeisimmäksi yliopistoyhteistyön vaikutukseksi arvioitiinkin yrityksen lisääntynyt tieto-taito; noin neljä viidesosaa yhteistyötä tehneistä yrityksistä arvioi, että se oli lisännyt yrityksen tieto-taitoa jossakin tai huomattavassa määrin. Näin ollen yritystenkin näkökulmasta yliopistojen keskeinen tehtävä olisi uuden tieteellisen tiedon tuottaminen. Havainto käy myös yksiin tutkijahaastatteluiden kanssa: yhteistyötä tekevät yritykset etsivät tietoa, eivät välttämättä suoria sovelluksia. Tämä on luultavasti ymmärrettävä sitä taustaa vasten, että yhteistyötä tekevillä yrityksillä on useimmiten myös omaa t&k-toimintaa, joka mahdollistaa yrityksessä tapahtuvan varsinaisen tuotekehitystyön.

Kuten tutkijat, myöskään yhteistyötä tehneet yritykset eivät raportoineet merkittävistä yhteistyöhön liittyvistä ongelmista tai jos ongelmia oli ollut, ne arvioitiin pääsääntöisesti vähäpätöisiksi. Useimmiten ongelmien katsottiin liittyvän kommunikaatioon, joidenkin partnereiden passiivisuuteen, heidän osaamiseensa tai rahoitusvaikeuksiin. Näissäkin tapauksissa kaksi kolmesta vastaajasta ei ollut kohdannut lainkaan ongelmia. Mielenkiintoista kyllä, tutkimustulosten luottamuksellisuus oli muodostanut ongelmia vain kymmenesosalle vastaajista ja immateriaalioikeudet viidesosalle vastaajista, lisäksi vain alle viisi prosenttia vastaajista arvioi nämä ongelmat vakaviksi.

Kaiken kaikkiaan yrityskyselyn perusteella on mahdollista päätellä, että yritykset kokevat yliopistollisella tutkimuksella olevan merkitystä teolliselle kehittämistoiminnalle ja että suhdetta oltaisiin myös halukkaita kehittämään edelleen. Ongelmina ovat kuitenkin esimerkiksi yrityskentän vaihtelevat resurssit rahoittaa ja hyödyntää tutkimustietoa sekä puutteellinen informaatio yhteistyömahdollisuuksista.

Keskustelua

Viime vuosikymmenen aikana yliopistokoulutukseen ja tutkimukseen kohdistetut odotukset ja vaatimukset ovat kasvaneet merkittävästi. Samalla kun yliopistojen tulisi tarjota ympäröivälle yhteiskunnalle entistä enemmän palveluita, yliopistojen odotetaan huolehtivan myös entistä tehokkaammin perinteisistä tehtävistään: peruskoulutuksesta ja -tutkimuksesta. Voidaan kuitenkin kysyä, ovatko vaatimukset ylimitoitettuja? Onko yliopiston mahdollista huolehtia kaikista sille osoitetuista tehtävistä mielekkäästi vai onko seurauksena toiminnallinen ylikuormitus?

Eräs ongelma on se, että yliopistoja kehitettäessä niitä harvoin tarkastellaan toiminnallisina kokonaisuuksina. Niinpä yliopistollista tutkimusta ja koulutusta kehitetään ja ohjataan paljolti toisistaan erillisillä politiikoilla ja hallinnollisilla päätöksillä. Koska tehtävien yhteensovitus ja odotuksiin vastaaminen jäävät usein viime kädessä laitostasolle, kokonaisuuden tasapainoinen kehittäminen on vaikeata.

Sisäisen synergian kehittäminen onkin nykytilanteessa eräs keskeisistä yliopistoja kohtaavista haasteista. Ilman synergiaa ja tehtävien koordinointia yliopisto kokonaisuutena on vain sateenvarjo toiminnoille, joilla ei juurikaan ole yhteyttä toisiinsa. Ulkopuolisen rahoituksen lisääntyminen ja uudet liiketoiminnalliset toimintamallit luovat myös organisatorisia jännitteitä. Uusien ja vanhojen tehtävien, sekä uuden ja vanhan yliopistokulttuurin välisessä jännitteessä kokonaisuuden hallittu ja tasapainoinen kehittäminen on suuri haaste.

Merkittävän ongelman muodostaa myös käytettävissä olevien resurssien rajallisuus. Vaikka budjetin ulkopuolisen rahoituksen kasvulla on eittämättä ollut myönteisiä seurauksia yliopistojen tutkimustoiminnalle, samanaikaisesti riittämättömät budjettivarat tekevät useimpien tutkimusorganisaatioiden sisällöllisen kehittämisen vaikeaksi. Kokonaisuuden pitkäjänteinen kehittäminen on vaikeata, jos se riippuu merkittävästi maksullisen palvelutoiminnan ylijäämästä. Kokonaisuuden kehittäminen vaatisikin uudenlaisia aloitteita niin valtion kuin yliopistojenkin taholta: rakenteellisia muutoksia ja strategisia avauksia, joilla taataan toimivat suhteet yhteiskuntaan mutta myös akateemisen 'ytimen' toiminta samanaikaisesti.

Toisaalta yliopistot jakautuvat useisiin tiedekuntiin ja oppiaineisiin sekä erillisiin tutkimus- ja palveluyksiköihin. Tämä diversiteetti ohitetaan usein kun yliopistoja tarkastellaan innovaatiojärjestelmän näkökulmasta. Ongelmaksi tämä muodostuu silloin, jos yksinkertaistus tuottaa myös yliopistoihin kohdistuvia poliittisia vaatimuksia, joissa yliopistot, tieteenalat ja erilaiset tutkimusympäristöt nähdään ikään kuin homogeenisena massana. Jokaisella tieteenalalla ja yliopistolla on kuitenkin sille ominaisia kehittämistarpeita, joita tulisi tarkastella myös tämän tai tuon tieteenalan tai yliopiston näkökulmasta. Yhdenmukaiset vaatimukset tuottavat myös paineita yhdenmukaistaa organisaatioita ja toimintamalleja, mikä ei puolestaan ole tarkoituksenmukaista, jos tilannetta tarkastellaan esimerkiksi jonkin tietyn tieteenalan tai tutkimusyksikön kehittämisen kannalta.

Samanaikaisesti on kuitenkin tärkeätä pyrkiä tukemaan järjestelmän sisäisiä kytkentöjä ja ruohonjuuritason verkostoitumista niin akateemisen maailman sisällä kuin sen ulkopuolellakin. Voidaan sanoa, että keskeinen haaste on huolehtia samanaikaisesti yhtäältä tutkimusorganisaation riittävästä sisäisestä integraatiosta ja diversiteetistä ja toisaalta sen ulkoisesta yhteiskunnallisesta vaikuttavuudesta.

Keskeisenä avainkäsitteenä voidaan pitää erilaisten toimintojen tasapainottamista. Tasapainoisen tutkimus-, kehittämis- ja innovaatiopolitiikan tulisi tunnistaa keskeisten toimijoiden toisistaan poikkeavat toiminnan päämäärät ja kompetenssit. Vastaavasti tutkimusyhteistyön tulisi perustua partnereiden keskinäiseen täydentävyyteen ja toiminnalliseen työnjakoon sen sijaan, että tietoisesti tai tiedostamatta eliminoidaan organisaatioiden välisiä eroja. Yhteiskunnallisesti relevantin tiedon tuotannon pitkäjänteinen kehittäminen edellyttää myös tutkimus- ja innovaatiojärjestelmän sisäisen pluralismin ja diversiteetin tukemista.

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Appendix 1. Remarks on the data

Statistical data

The statistical data used in the study were derived from official R&D funding statistics compiled by Statistics Finland. One aim of the study has been to describe changes in R&D funding during the 90s and analyze its variation from different perspectives; there have been, however, no ready-made tables available. For instance, no comprehensive longitudinal tables are publicly available for this purpose. Therefore the longitudinal data has been collected from available biannual R&D statistics during the 90s and indexed to 1998, which was the most recent year covered by the statistics when this study was conducted. In February 2001, when this was written, the information from the year 1999 was still unavailable (from 1999 onwards R&D statistics have been collected annually).

In the formulation of statistics, Statistics Finland has used recommendations given by the OECD and from 1995 onwards also recommendations given by the EU. All the presented figures are research expenditures; education-related expenditures are excluded. In general, the comparability of longitudinal data is satisfactory. However, there have been some changes in the statistics during the 1990s and in these cases the original figures have been corrected in order to make figures comparable. University hospitals were included in the statistics for the first time in 1997. As it distorted severely the comparability of the figures it has been removed in our effort to 'clean up' the statistics. In addition, veterinary science was included in medicine from 1997 onwards, although previously it belonged to agriculture and forestry. These statistics were corrected to correspond to 1998 situation. There are still, however, some unclear questions in the classification of disciplines that might, in turn, cause some minor problems in the comparability of disciplinary groups in 1997—98.

Interview data

The aim of the interviews was to examine, how researchers see non-academic research collaboration and what kinds of consequences it has had for the research enterprise. The interview scheme included questions on partners, forms of cooperation, knowledge transfer, and problems of cooperation (for the scheme see Appendix 2). The data consists of 19 semi-structured interviews. Each interview, lasting approximately one and a half hours, was recorded on tape and transcribed afterwards. In the written form, the data comprises approximately 400 pages. The interviews were conducted between October and December 2000.

The interviewees were selected from among senior researchers in university departments and research units that cooperate on a continuous basis with non-academic partners. Most of the interviewees were professors, research directors or experienced senior researchers. In addition, three research liaison officers from two universities were interviewed. In terms of academic background, five interviewees were social scientists; five had a technical background; four were from a medical faculty; two were from a natural scientific faculty, and one was from a faculty of business administration. Altogether the interviewees represented five different research units and seven departments. The departments were from medical, technical and natural scientific faculties and the research units represented social scientific, business administration and technologically oriented multi-disciplinary research. The interviewees were from the University of Tampere, Tampere University of Technology and University of Jyväskylä (for a list of interviewees see Appendix 3).

Methodologically the selected departments and units are thought of as typical cases which represent a wider variety of units acting in a relatively similar environment, including a lot of external funding and a variety of external, non-academic, contacts (c.f., e.g., Alasuutari 1993). While it cannot be denied that each department or unit has its own specific features, the common features of departments and units may tell us how a typical university department or unit, which has extensive non-academic cooperation, acts. Interviewees are treated in this study as informants, i.e., representatives of their institutions. Our interest was predominantly in describing and analyzing how things are from the researchers' perspective (so called 'factual approach', ibid.), not, for instance, in how interviewees construct in different discourses their lives as researchers. The data 'saturated' rather fast regarding the problems we were interested in during this study. It was rather obvious already after approximately 10 interviews that the basic story would not change, even though there was, naturally, variation in the details.

Survey data

Survey data was utilized in order to analyze university-industry interactions from the firm perspective. The analysis is based on the survey that was conducted during 1998-99 in collaboration involving the Science Studies Unit and Research Group for Systems of Innovation and Organizational Learning at the University of Tampere.[13]

The questionnaire included questions about the nature, intensity, problems and development possibilities of collaboration. (As the questionnaire was in Finnish, it has not been appended to this study. For those who are interested in the questionnaire, it is available in the Science Studies Unit, University of Tampere.) The survey was sent out to 1 480 companies in the Tampere, Turku and Oulu regions. The sample covered all the manufacturing companies that employed over ten persons and all the companies employing over five persons in the central

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[13] The project was a subproject of a research project called "University research in transition" (leader: Erkki Kaukonen) funded by the Academy of Finland. The survey was conducted by Gerd Schienstock (leader), Petri Roponen, Mika Kautonen and Mika Nieminen. The results have not been published or reported in this form earlier.

knowledge-intensive business service sectors (KIBS)[14]. The three regions were chosen, since after the Helsinki region, they are the most R&D-intensive areas in Finland as measured by R&D investments. The companies were selected randomly from a database provided by Statistics Finland.

The questionnaire was completed by 374 companies, the rate of return being 25%. The rather low rate of return is not surprising. Top company managers are usually busy and they do not have time to respond to questionnaires. In the feedback, a frequent comment was that the questions did not fit in the company profile – especially if the company did not have R&D activities. This might be one reason for the low rate of return. If a company did not have R&D activities, the respondent may have interpreted it as unnecessary to respond to a questionnaire in which most of the questions were linked to R&D activities.

Regionally the sample was representative. 39 percent of the questionnaires were sent out to the Tampere region, 39 percent to the Turku region and 22 percent to the Oulu region. Of the companies which returned the questionnaire, 36 percent were in the Tampere region, 42 percent in the Turku region and 22 percent in the Oulu region.

According to size most of the firms surveyed were employing from ten to 49 employees. Only one fifth of the firms were small, employing under ten persons. Likewise, under one tenth of the responding firms employed over 200 persons. According to Statistics Finland, of the Finnish manufacturing firms which in 1998 employed over five persons, over 40 percent were small ones, employing from five to nine persons. 'Middle rank' firms employing from 50 to 249 persons totaled 12 percent of manufacturing firms and big companies employing over 250 persons only approximately 4 percent. From this perspective, the sample is under-representative in the small-firm category and over-representative in the medium-sized category. We have to remember, however, that only manufacturing companies employing over ten persons were selected for the sample, which is reflected in the fact that in the sample the knowledge-intensive business service firms were more likely small ones employing under 20 persons (63% of KIBS companies in the sample) than big ones employing over 200 persons. Medium low or low-tech companies as well as the high or medium high-tech companies were more often employing over 20 persons (a little over 60% in each category). Medium low or low-tech companies in the sample were, however, usually employing fewer than 200 persons.

Altogether 64 percent of the respondents represented industrial enterprises and 36 percent knowledge-intensive business services. According to technology intensity, 37 percent of the respondents can be placed in the category of low or medium low-tech, 27 percent in the category of high or medium high-tech, and

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[14] Post and telecommunication, data processing services, research and development, patent offices, market surveys, consultancy, technical service and testing, labor leasing and industrial art and planning.

36 percent in the category of knowledge-intensive business services. In 1997, 1.5 percent of the Finnish manufacturing companies belonged to the high-tech category, 21.4 percent to the medium high-tech and 77 percent to the low tech category (Statistics Finland 1999)[15]. A clear over-representation of high-tech and medium high-tech companies in the sample also supports the idea that mostly those companies responded that have in-house R&D activities.

In the following table, the respondents are divided into seven categories according to the branch of industry (originally the respondents had been divided into 23 categories on the basis of a classification used by Statistics Finland and then were re-classified into seven categories)[16]. Services comprise the biggest single category among the respondents, the metal industry (basic metal and mechanical engineering together) occupying the second position. The information and communication sector makes up only one tenth of the sample. On the basis of comparison of the sample and the actual situation shown in the statistics, it can be said that the sample is a little over-representative in the categories 'chemical industry', 'basic metal', 'mechanical engineering', and 'instruments and equipment'. The sample of ICT companies corresponds well to the actual situation while the proportion of 'services' and 'other' is a little under-representative in the sample.

	Sample	**Regions**
Chemical Industry	15	4
Basic metal	14	9
Mechanical engineering	11	8
Instruments and equipment	12	4
ICT	9	10
Services	27	39
Other	13	26
Total	100	100
(N)	(372)	(14215)

Table 25. Respondents and firms in the regions according to branch of industry.

[15] Statistics Finland does not compile statistics on KIBS firms.

[16] These categories include the following sub-categories. Chemical industry: production of coke and oil-products, chemicals, rubber and plastic products, non-metal mineral production. Basic metal: production of metal products. Mechanical engineering: production of machinery and equipment. Instruments and equipment: production of office equipment, computers, radio and TV equipment, medical instruments. ICT: postal traffic and telecommunication, data processing services. Services: research and development, other business services. Other: production of food, drinks and cigarettes, textile production, clothing industry, production of timber and wood products, printing and publishing, production of cars and trailers, other production of vehicles, production of furniture, recycling.

In the majority of the responding companies, the turnover was between 10 and 50 million FIM. In 18 percent of companies, the turnover was over 50 million FIM. The breakdown of the turnover among the sample companies can be compared to that of the Finnish manufacturing industry – even though the statistics provided by Statistics Finland do not use the same turnover categories. In half of the companies, the turnover has remained below 500 000 FIM. The turnover is between 10 and 50 million FIM in 6.4 percent of the companies and in the category over 50 million FIM, there is only 3.1 percent of all companies. Finnish manufacturing companies are thus usually rather small measured by the amount of turnover. As the sample was comprised of firms employing at least ten persons, it is rather difficult to compare the lowest categories with each other. However, the sample is over-representative in the highest categories. For instance, in the category from 10 to 50 million FIM, the sample included 23 percent of the companies in that range, while in the whole population only 6.4 percent of the companies can be placed in this category.

As a conclusion, it can be said of the data analysis that the reader has to be cautious when making interpretations on the basis of the data. Especially Finland-wide generalizations might be biased since the sample is not corresponding well enough to the structure of Finnish industry as a whole. An additional reservation should be expressed because the target populations are the most R&D-intensive regions in Finland (after the Helsinki region). The overall picture of Finland might be different. However, in spite of this, the data provides insight into Finnish industry-university collaboration from the firm perspective. As a whole, the data represents industry well enough, even though the generalizations based on smaller group divisions, like according to branch of industry, may be biased. In addition, it can be estimated that the sample informs us quite well as to how the collaborating firms see university-industry relations.

Appendix 2. Interview schema

0. Department's/ Unit's/ Research group's background: focal research and teaching areas, number of personnel, share of external funding, current targets for activity, organization etc.

1. With whom has the department/unit/research group had 'non-academic' collaboration?

   What kind of role do the different partners have?
   How does academic and non-academic cooperation relate to each other?
   What kind of network is constructed on the basis of these contacts (How do they support each other; mutual significance etc.?)?

2a. What forms does collaboration take?

For instance:

University-based institutes serving societal/industrial needs
Jointly owned or operated laboratories
Research consortia
Contracted university research
Government-funded co-operative research programs
Patenting and licensing
Continuing education
Consulting
Personnel exchange
Seminars, publication exchange

2b. How significant are these different forms for the department/research unit/ research group?

2c. How 'interactive' is the collaboration by nature? Does it vary according to partner and form of collaboration?

3. How does knowledge transfer/dissemination take place? Concrete examples? What kind of relationship is there between codified and tacit knowledge?

4a. Why has collaboration been started and who is usually the initiator?

4b. Do change of science policy, new funding instruments, development of basic funding etc. affect the background of collaboration?

5. How are different forms of collaboration, partners and research activities accommodated to each other in the whole of research activity – are there, for instance, problems in relating basic research activities to applied research activities and vice versa? How is this done?

6. Is there currently too much, too little, or a suitable level of contacts and collaboration?

7. Does collaboration involve any specific problems? Is it possible to develop collaboration somehow? Should it, for instance, be organized differently or is the current way appropriate?

    Examples of potential problems:
    Dependency on financier
    Power relation/steering
    Different time spans in action
    Partner's know-how
    Knowledge transfer
    Secrecy of research results
    Communication problems
    Different ways of thinking/cultural differences
    Leadership/coordination
    Too ambitious targets
    Different (technical) solutions and instruments
    Finance
    Intellectual property rights
    Partner's unrealistic expectations of the possibilities of research

8. What effects has collaboration had for the department's/ unit's/research group's research activity?

9. What kind of expectations does the department/unit/research group have for the development of collaboration in the future?

Appendix 3. Interviewed persons

Aho Simo, Senior researcher, University of Tampere,
Work Research Centre, 6.11. 2000

Airila Susanna, Research liaison officer, University of Tampere, 25.10. 2000

Heinonen Ari, Senior assistant, University of Tampere,
Research Unit for Journalism and Mass Communication, 1.12. 2000

Koski Pasi, Senior researcher, University of Tampere,
Work Research Centre, 1.11. 2000

Kuhanen Pirjo, Research liaison officer, Tampere University of Technology, 30.10. 2000

Kautonen Mika, Senior researcher, University of Tampere,
Work Research Centre, 25.10. 2000

Kivikoski Markku, Professor, Tampere University of Technology
Department of Electrical Engineering, 21.11. 2000

Mäntylä Tapio, Professor, Tampere University of Technology
Institute of Materials Science, 7.11. 2000

Raittila Pentti, Research director, University of Tampere,
Research Unit for Journalism and Mass Communication, 1.12. 2000

Suontamo Tuula, Senior researcher, University of Jyväskylä,
Department of Applied Chemistry, 28.12. 2000

Talonen Harri, Research director, University of Tampere
Research Unit for Business Economics, 1.11. 2000

Timonen Jussi, Professor, University of Jyväskylä,
Department of Physics, 28.12. 2000

Tähti Hanna, Research director, University of Tampere,
Medical Faculty, 8.11. 2000

Vesikari Timo, Professor, University of Tampere,
Medical Faculty, 31.11. 2000

Viikki Jorma, Research liaison officer, University of Tampere, 25.10. 2000

Vilenius Matti, Professor, Tampere University of Technology
Institute of Hydraulics and Automation, 23.11. 2000

Virtanen Ilkka, Research secretary, University of Tampere
Medical Faculty, 24.10. 2000

Viteli Jarmo, Professor, University of Tampere,
Multi-Media Laboratory, 3.11. 2000

Ylikomi Timo, Professor, University of Tampere, Medical Faculty, 21.11. 2000

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