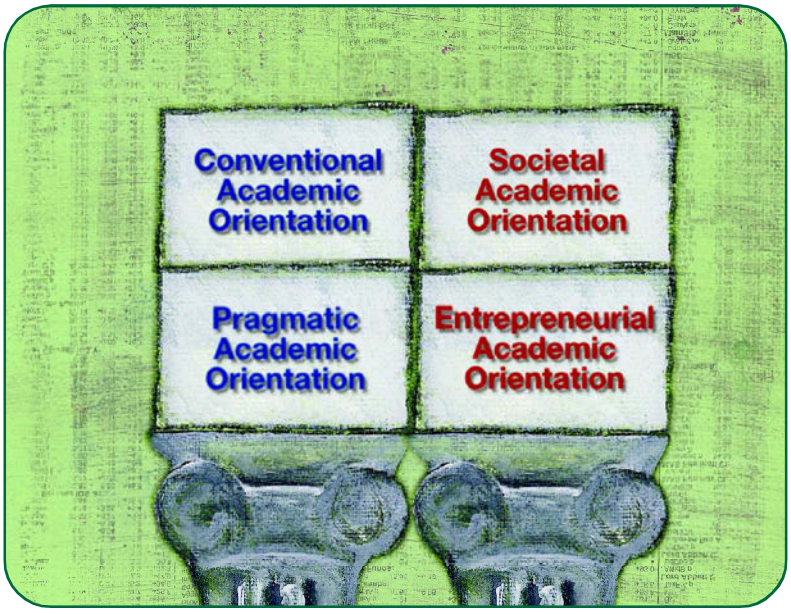
ESPOO 2005 VTT PUBLICATIONS 589



Pirjo Kutinlahti

Universities approaching market

Intertwining scientific and entrepreneurial goals

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Pirjo Kutinlahti
VTT Technology Studies

ACADEMIC DISSERTATION

To be presented, with the permission of
the Faculty of Social Sciences of the University of Helsinki,
in Auditorium XII, University Main Building,
on January 28th, 2006, at 12 o'clock.

ISBN 951–38–6690–4 (soft back ed.)
ISSN 1235–0621 (soft back ed.)

ISBN 951–38–6691–2 (URL: http://www.vtt.fi/inf/pdf/)
ISSN 1455–0849 (URL: http://www.vtt.fi/inf/pdf/)

JULKAISIJA – UTGIVARE – PUBLISHER

VTT, Vuorimiehentie 5, PL 2000, 02044 VTT
puh. vaihde 020 722 111, faksi 020 722 4374

VTT, Bergsmansvägen 5, PB 2000, 02044 VTT
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Technical editing Anni Kääriäinen

Valopaino Oy, Helsinki 2005

Kutinlahti, Pirjo. Universities approaching market. Intertwining scientific and entrepreneurial goals. Espoo 2005. VTT Publications 589. 187 p. + app. 4 p.

Keywords entrepreneurial universities, academic research, knowledge creation, knowledge dissemination, knowledge exploitation, SMEs, academic rationale, economic rationale, societal rationale, innovation activities

Abstract

In the past decades universities have progressively gained more attention for their roles as economic actors. Not only are they held responsible for generating intellectual value, but also for delivering more direct benefits to both society and economy. Such a wider and, at the same time, extremely complex new role of universities poses serious challenges to universities. They struggle to solve the dilemma of how to make academic research institutions accelerate the production of socially and economically relevant knowledge and, at the same time, improve the quality of knowledge produced, without restricting the relatively autonomous governance structures characterising the academic system. The major challenge that universities face is the integration and simultaneous accomplishment of their knowledge creation, knowledge dissemination and knowledge exploitation functions.

In an endeavour to shed light on such a multifaceted issue, the present study focuses on the characteristics and impacts of entrepreneurial university by analysing the university-industry-government relations and the university engagement in commercialising research. Using data from several surveys and interviews conducted with Finnish university staff and firms participating in the EU framework programmes, the study highlights the possible gains, losses and tensions determined by the entrepreneurial activity of public research institutions, as well as the significance of universities within the knowledge production and innovative activities of firms.

The present study further develops Donald Stokes' (1997) typology concerning the structural, cultural and organisational elements characterising university's exploitation of academic research. In order to go beyond linear thinking and taking into account the cognitive dimension of integrating academic and utilitarian demands, the study proposes a conceptual model, which may

represent a useful tool in order to address the challenges and tensions that the university system faces when and if engaged in entrepreneurial activities. Furthermore, it highlights the importance of pluralism and analyses university's extending role, which goes beyond research and education and encompasses dissemination and utilisation of research results, to the benefit of both the economy and society.

The findings of the study show that scientific and entrepreneurial goals can be intertwined, although tensions and conflicts of interest may arise. The latter may emerge from the confrontation of different research culture and normative structure, rather than because of the divergences between basic and applied research. Knowledge exploitation is a question of reconciling cognitive differences and emphasising similarities, as well as balancing different responsibilities and demands. The bargaining process between university and industry is important for the success of the collaboration. A mutual understanding of the project's goals and the creation of a win-win situation among the partners involved in the research project are factors that enhance the potential success of the collaboration. Trust, mutual respect and understanding seem to be of crucial importance to firms, when they collaborate with universities. A set of managerial skills seems to be required to enable the universities' entrepreneurial behaviour. In fact, those university institutions that are at ease with the idea of bringing the work of their researchers into closer contact with market-oriented industrial R&D projects, have promoted a business-like management culture and seem to have an advantage in the research market. In this respect, the analysis also highlights the importance of an inspiring and goal-oriented leadership, in order to facilitate the entrepreneurial activities.

However, it must be noted that not all fields of science may suitably accomplish an entrepreneurial role, nor do all academics possess the relevant competencies with which to carry out some of the entrepreneurial activities. The entrepreneurial engagement may have some counterproductive consequences for the university system. Competitiveness may create disincentives for researchers to engage in projects where they cannot present quantifiable outputs. Academics may also become reluctant to contribute to educational and training tasks and be less motivated to carry out those research projects with a long-term horizon.

Acknowledgements

"To replace the linear model of the post-war paradigm, we need a clearer understanding of the links between the dual but semiautonomous trajectories of basic scientific understanding and technological know-how."

Donald E. Stokes, 1997

Stokes' reasoning of the relationship between scientific work and its utilisation has provided the theoretical inspiration to carry out this dissertation. For me, the most intriguing issue has not been whether the universities' engagement in entrepreneurial activities is a good or bad thing but rather does this activity bring something qualitatively new to scientific development? My study has convinced me that issues such as managing university-industry relationships and strengthening academics' entrepreneurial skills are significant for the dissemination of research and balancing the different university functions.

This dissertation was carried out in 2003–2005 at VTT Technology Studies. The data used was, however, collected in several evaluation studies during 1998–2003. An almost ten-year period in exercising evaluations on the impacts of the EU framework programmes on the Finnish research system and universities in particular has given me a good opportunity to follow the longer-term developments of these programmes as well as inspiration for seeking a deeper theoretical understanding of the studied phenomena. The data was modified for the academic purpose with financial support from VTT and the ProACT-programme, jointly financed by the National Technology Agency and the Ministry of Trade and Industry, which are both gratefully acknowledged.

This work owes a great deal to the interest of a number of people. First of all, my deepest gratitude to my supervisor, Professor Marja Häyrinen-Alestalo, who has patiently commented on the earlier versions of the thesis and given me advice on how to improve it. I am enamoured by the energy and devotion that she places on the guidance of her doctoral students. Professor Merle Jacob from the University of Lund and Dr. Oili-Helena Ylijoki from the University of Tampere as manuscript reviewers are thanked for giving a number of important and valuable suggestion that helped me to clarify the analysis. I am also indebted to my colleague Mariagrazia Squicciarini at VTT Technology Studies for her

invaluable assistance in correcting the English language and finalising the manuscript during the very last months. Her suggestions have significantly improved the final text.

It is largely thanks to my good friend and former colleague Terttu Luukkonen that I have taken this academic effort. Our discussions and working together for several years have affected my thinking and provided me with an idea to continue my studies. I am grateful to Tarmo Lemola, who appointed me to the Group for Technology Studies at VTT in 1995. He also made the financial support available to me and made this thesis possible. I have had the privilege of working in an excellent environment at VTT. The Research Manager of VTT Technology Studies, Torsti Loikkanen, is thanked for a positive attitude towards my academic work. Researchers Kirsi Hyytinen, Jukka Hyvönen, Bernd Ebersberger, Juha Oksanen, Sasu Hälikkä and Marjo Uotila are thanked for contributing to the data collection. I also benefited from the insightful comments of Soile Kuitunen, Jani Saarinen, Eveliina Saari and Mari Rantanen during the early phases of writing the thesis. I am also grateful to all of the members of VTT Technology Studies for supporting me. Likewise, I thank all respondents and interviewees in Finnish universities and firms for giving me their valuable time to respond my questions.

During my working career I have learnt a great deal about science and technology issues as well as research work from several people outside VTT. Ulla Ekberg, who was my former superior between 1987–1995 at the Academy of Finland, and Esko-Olavi Seppälä, the Chief Planning Officer of the Science and Technology Policy Council of Finland are thanked for giving me support during the early years of my research career. I am also grateful to Niina Elo and Kari Kankaala, who have counselled me not only in the juridical aspects of commercialisation but helped me to understand the core problems of the issue. Research colleagues Johanna Hakala, Mika Nieminen and Erkki Kaukonen from the University of Tampere are thanked for interesting collaboration in studying the ongoing developments of Finnish universities. Special thanks to Mika Nieminen, who gave invaluable advice in revising the manucript. Writing in English has been one of the most challenging and difficult tasks for me. Kylie Bull and Amanda Thurman from Bellcrest Translation are thanked for correcting my English usage. The care and the support received from my close friends, Sinikka Aapola, Anne Mutka and Anita Westerback are not forgotten. I also

thank Virpi Vesterinen, Eero Kempas, Jarkko Huuskonen, Marko and Maija Hyytiäinen for their constant support and the enjoyable social events I have spent with them.

I want to express my sincerest gratitude to my twin sister Marjo Aaltomaa, to whom this thesis is dedicated, and her husband Esa. Marjo's support and caring attitude during the past twenty years has helped me to reach this academic path. I want also to thank my parents, Eivor and Ilpo for giving me a lifetime of backing and support. I thank my sister Tarja, brothers Jari, Jyrki and Jan as well as all other members of my family for having good memories from our childhood and family events. I also wish to acknowledge my father-in-law Veikko Kutinlahti for his interest towards my work. His devotion to utilise academic research findings for forest regeneration is something extraordinary. Most of all, I want to thank my husband Timo for his support and love during the eight years we have been together. Timo, I am so happy that you are sharing this unforgettable experience with me.

Helsinki, December 2005

Pirjo Kutinlahti

Contents

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1. Introduction

The present study addresses the emerging entrepreneurial norm in universities by examining the university-industry-government relationship and university engagement in the commercialisation of research in Finland in the late 1990s and early 2000s. Of particular consideration here is whether scientific and entrepreneurial goals can be intertwined in academia.

The deepening ties between universities and industry as well as the commercialisation of academic research have been the subjects of intense policy and research interest since the mid 1980s. Universities have become more active in trying to commercialise their research and in establishing linkages within industry. Furthermore, different types of policy schemes and programmes have been launched to support university-industry collaboration and commercialisation of results generated by public research institutes. These developments have given rise to the phenomenon of the entrepreneurial university (Clark 1998; Etzkowitz et al. 2000; Jacob et al. 2003). Today policymakers tend to consider entrepreneurial activities as the universities' 'third function', which encompasses the economic development in addition to education and research functions (Etzkowitz 1989, 2003). The concept of 'entrepreneurial university' refers to the adoption of the dual cognitive research mode focusing on achieving fundamental advances in knowledge and inventions that can be patented and marketed (Webster & Rappert 1997). These developments have occurred more or less rapidly within different countries and the field of sciences (Senker 2003; Nieminen 2005).

Undoubtedly, the growth of entrepreneurial activity in universities turns out to have multiple causes. On the one hand, some scholars in the field of science and technology studieshave feared that greater involvement with industry and the commercialisation of research may corrupt academic research undermining the commitment to teaching and research as well as the openness of academic research (Feller 1990; Faulkner & Senker 1995; Senker et al. 1998; Ziman 1994, 1996; Cohen et al. 1998; Blumenthal et al. 1997). Evidence from Finland has also shown that harmonising and balancing the entrepreneurial activities with the universities' traditional functions cause tensions (Niskanen 2000; Tupasela 2002; Pelkonen 2001; Tuunainen 2004; Häyrinen-Alestalo & Peltola 2004; Nieminen 2005). The changes in university behaviour may also cause concerns

with universities being perceived as competitors of firms rather than partners (Rappert & Webster 1997). On the other hand, recent literature offers evidence regarding the beneficial impact of market-oriented activities. Research collaboration with industry may provide access to complementary expertise and increase knowledge exchange between the public and private science (Tuunainen 2004; Nieminen 2004, p. 192).

Despite growing interest to the entrepreneurial role of universities, a number of questions still remain open. It is still uncertain how academia can encompass a mission of economic development in addition to research and teaching. Further study is required into the positive and negative impacts of entrepreneurial engagement on universities' orientation, positioning and capacities. More information is also needed about the role and contributions of the universities in relation to the innovative activities of firms. Using data from several surveys and interviews conducted among Finnish university staff and firms who participated in the EU framework programmes, the present study provides insights into the possible gains, losses and tensions determined by the entrepreneurial activity of universities. The potential contributions of universities to the innovative activities of firms and commercialisation of research results are also addressed. The perspective adopted in this study builds upon the premise that any consideration of the impacts of the deepening ties with industry and commercialisation on academic research requires an understanding of the impetus behind these relations.

Few research programmes have been evaluated and studied as much as the EU framework programmes (see e.g. de Montgolfier & Husson 1995; Luukkonen & Niskanen 1998; Ohler et al. 1998; Niskanen 2001; Luukkonen & Hälikkä 2000). These studies have, however, mainly focused on the industrial implications of EU-funded projects, considering remarkably little the impacts of EU participation on university research. The EU framework programmes offer an interesting case to study the potential positive and negative effects of university-industry linkages on academic research. Furthermore, because these programmes are aimed at fostering scientific excellence and competitiveness of European industries, it is also possible to study the validity of the claim that goals of fundamental understanding and practical use are not inherently in conflict but mutually beneficial. It has been argued that there are many instances where academically valuable knowledge can emanate from research with practical

goals and vice versa, where commercially valuable knowledge results from more academic oriented research (Stokes 1997; Brooks 1968; Rosenberg 1982).

Studying the interaction between universities and industry in the EU framework programmes also proves to be an interesting research objective from a historical and policy perspective. Finland has recently experienced exceptional success in technological development, thus becoming one of the leading innovative countries in the world. Analysing the significance of EU funding in facilitating the university-industry linkages offers knowledge about the role of public programmes in enhancing Finland's success. Such information would be of vital importance in supporting the policy debate concerning the future role of these programmes in promoting the dissemination and utilisation of academic research.

The study proceeds as follows. Chapter 2 outlines the conceptual framework used to explain the entrepreneurial behaviour and role of universities. The theoretical basis from which to explain the role of universities in creating, disseminating and utilising knowledge is outlined from the academic, economic and societal rationales within the social contract of science. These three perspectives underline both the internal and external factors affecting universities' behaviour. Furthermore, the concept of Pasteur's Quadrant is chosen to illustrate the various university approaches to market needs. This model suggests a new two-dimensional conceptual framework where many degrees to commitment to seek fundamental understanding and consideration of use may exist. Pasteur's work is used to illuminate a paradigmatic example of "use-inspired" basic research. This type of research seeks to extend the frontiers of understanding but is inspired by consideration of use. Chapter 3 specifies the research questions and introduces the empirical data used in the present study. It also further develops the quadrant model of university approaches to market demand. With the help of quadrant model, the analysis focuses on the extent that Finnish academics are responsive to the entrepreneurial ideology and whether they share the view that scientific research and practical use can be achieved simultaneously.

Chapter 4 introduces the analysis of the government by looking at the national policy framework for university-industry interaction and commercialisation of academic research, given that Finnish universities are highly dependent upon the

resources provided by the political system. In Chapters 5–6, attention is given to incentives, barriers and benefits arising from research collaborations between universities and industry. The focus is also on the relations and tensions between the diverse functions of university as well as the cultural and organisational factors affecting the emergence of an entrepreneurial university. The aim is to highlight how Finnish universities have responded to the entrepreneurial demand on the one hand, and the significance of their economic role in the firms' innovative activities, on the other. The interaction between universities and industry and the entrepreneurial role of universities are analysed by using interview and survey data conducted among Finnish university staff and firms in late 1990 and early 2000s. The analysis also entails the strategic importance of public support in creating research linkages between universities and industry.

The study ends in a discussion of the main benefits and challenges that universities face when engaging in commercialisation, thus paving the way for a better understanding of the entrepreneurial role of universities and identifying some possible future research questions. Inevidently scientific and entrepreneurial goals can be intertwined, although tensions and conflicts of interest may arise. The latter may emerge from the confrontation of different research cultures and normative structures, rather than because of the divergences between basic and applied research orientation.

2. Explaining the entrepreneurial university: academic, economic and societal rationales for science

The university-industry relationship and commercialisation of academic research have spawned two distinct but related strands of literature: one addressing the organisational and institutional characteristics of university behaviour and the division of labour between the public and private sectors of the R&D system. The other stream of literature has endeavoured to understand the contributions of 'public science' to technological development and innovation as well as processes by which knowledge generates wealth.

This chapter endeavours to integrate these two streams of literature by addressing the role of universities in knowledge production through three analytical perspectives: academic, economic and societal. These perspectives or rationales can be seen as co-existing processes that shape the understanding of the social contract for science.

The academic rationale for university considers universities as unique organisations influenced by academic norms such as autonomy, the quality of research and academic values. This approach departs from the functionalist approach concerning the cultural expectations of university research and constitutes the oldest of many streams of research regarding the social contract of science. Secondly, **the economic rationale** for university funding departs from the conceptual orientation of the 'new economics of science', developed by such scholars as Gibbons and Johnston (1975), Dasgupta and David (1994), Rosenberg (1986, 1998) and Nelson (1990). It postulates that universities are increasingly contributing to the economy and innovative activities of firms. The value of the economics of science empirically is that it provides insights into the economic role played by universities and their relations with the other producers and users of knowledge. It addresses the proximity and overlap between science, technology and innovation.

From the 1990s onwards an increasing number of scholars have focused their research efforts on the understanding of the transformation of universities. The economic rationale has given impetus to new conceptualisations of university

research behaviour such as “Mode 2 knowledge production” (Gibbons et al. 1994), new economics of science (Dasgupta & David 1994), “Triple Helix” (Etzkowitz & Leydesdorff 1997) and “Entrepreneurial Science” (Clark 1998; Etzkowitz et al. 1998, 2000). These conceptions are driven by the same forces and have similar overall aims, although the changes vary from country to country. Therefore, particular attention is given to the understanding of the changes and constraints facing Finnish universities.

Finally, the tentative approach is referred to here as **the societal rationale**, which tries to explain why science should create partnerships with other actors in society. This rationale challenges the two prevailing conceptions reflecting the step-by-step cognitive progression from linear thinking to a more robust understanding of the social contract of science. This does not imply that the academic rationale is abandoned in favour of the economic or societal one, but rather that these three rationales exist alongside each other. The societal perspective is provided only to refer to the continuation of the transformation process of universities. In the following, the emphasis of analysis will therefore be on the academic and economic rationales for university-industry linkages.

The following questions inform the analysis of these three rationales: what are the contributions of science to innovation, and to economic and societal development? What is the relationship between public and private science? What are the potential barriers and obstacles for commercialising academic research? After a discussion of these three rationales, the framework is further developed considering the three rationales to university research behaviour and funding.

2.1 The academic rationale

The academic rationale is seen to have been most influential from the post-war period until the 1980s. Until the 1970s, there was a great reliance on state funding for basic research and a high level of autonomy for both individuals and institutions. Academics were also given considerable autonomy in choosing their research topics.

The origin of the autonomy issue can be related to the seminal work of the American sociologist Robert Merton. In the 1950s, he began studying the organisational and behavioural aspects of the scientific enterprise. Merton's work was then extended through the work of his fellow functionalists, Storer and Hagstrom (Webster 1991). Even though it has been widely sensed in the sociology of science that the Mertonian approach is outmoded in explaining the developments in science, there are, however, two basic reasons why it deserves attention when analysing contemporary university development. Firstly, the Merton's norms are still the main source of ideas, perspectives and advice on how to interpret the social and cultural values of the university system. Secondly, the concept of academic ethos elaborated by Merton continues to be manifested in the contemporary debate regarding the detrimental influences of university engagement in commercial activities. To this end, the Mertonian account and his four social norms of science require a brief rehearsal.

Merton's (1973, pp. 267–278) main thesis was that academic science is governed by an "ethos", embodying a set of functional norms, which ensure that the members of the academic community are, in the course of their professional activities, self-critical, impartial and open-minded. Merton's norm *universalism* ensures that the quality of academic work will be evaluated on the basis of the work itself, not on the scientist's prestige or lack thereof. *Communalism* entails the sharing of research results and approaches with other researchers. It ensures that research will be open to all challenges, subject to verification by replication and widely disseminated. *Disinterestedness,* in turn, requires research to be detached from personal motives and pursued only for the sake of truth and intellectual interest. Finally, organised scepticism urges the critical and public examination of scientific work.

The Mertonian model is considered an "ideal type" that emphasises the role of academic science as the fullest embodiment of scientific ideals and practices, and the ultimate source of cognitive authority. In other words, science is an activity that depends on its practitioners being open-minded, impartial and self-critical. Thus, scientific knowledge is seen to be, in principle, socially neutral. As it assumes that there is a general conformity to the norms among scientists, it follows that the rapid growth of science can only occur within open communities without distortions and interventions coming from outside the scientific community.

The functional interpretation has been considered a highly idealised rationale for the scientific system among the sociologists of science. Mulkay (1979) and Gieryn (1982) have maintained that scientists use the rhetoric of norms quite variably, as contexts change, in order to justify their particular behaviour (Mitroff 1974; Mulkay 1979). Overall, according to Mulkay (1979), these norms should be regarded as "vocabularies of justification" (p. 77). More generally, the successful use of normative claims to justify specific behaviour helps to protect particular interest groups. Academic ethos has been an important constituent of a broader ideology stating what is perceived as good science.

Among the criticism of Merton, Cicourel's (1974, pp. 11–41) interpretation is of particular interest. He argues that rules of norm, in general, are not things to be defined by sociological analysts but are available for definition by those who act in everyday life. He suggests that rules do not translate into behavioural patterns in an immediate and direct way, but are decided collectively in a given setting. This view suggests that the rules of scientific conduct are exposed to continuous negotiation. What was unfavourable behaviour yesterday may today be considered acceptable.

In defence of the Mertonian approach, Gieryn (1982) instead argues that Merton's account underlines the distinctive characteristics of science compared to other forms of knowledge, such as religious beliefs or art. Gieryn reckons that the social norms of science have saved science from external political or cultural interference by highlighting how such intrusions compromise the necessary moral conditions, which in turn make the extension of certified knowledge possible. He believes that the distinctive feature of science is that nature impinges upon it, constraining and modifying what can and cannot be said about it (Ibid. 1982).

The Mertonian account has been criticised because of its static form and its strict boundary between public and private science. Merton tended to assume that the social system of science is fundamental and stable. The implicit motive for research, as well as the basis for rewards in academic work, is the pursuit of new knowledge. Indeed, in the Mertonian paradigm, those scientists engaging in "pure" or "basic" science are routinely distinguished from those researchers whose work is carried out in an "applied" context (Barnes & Edge 1982). Furthermore, maintaining an appropriate balance between basic research and

commercial objectives is a potential conflict of interest area, as it contrasts the openness of communication with the industrial interest in protecting intellectual property.

More recent critics have paid special attention to communalism and disinterestedness. Communalism requires research results to be shared with peers. As all research should be available for all, secrecy is its antithesis. The academic quest for eminence, involving the open disclosure of fundamental research, conflicts with the profit incentive of firms (Klevorick et al. 1994). In this respect, Dasgupta and David (1994) demonstrate the distinction between public and private science as follows:

> "It is the nature of the goals accepted as legitimate within the two communities of researchers, the norms of behaviour especially in regard to the disclosure of knowledge, and the features of the reward systems that constitute the fundamental differences between the pursuit of knowledge undertaken in the realm of Technology and the conduct of essentially the same inquiries under the auspices of the Republic of Science. What matters is the socio-economic rule structures under which the research takes place, and most importantly, what the researchers do with their findings." (P. 495.)

The above argument maintains that there is no difference between basic and applied research. The boundary between the two realms reflects the division of labour between public and private science and the difference in the reward systems. This conflict between incentives for academics and those for firms suggests that to secure industry support or to otherwise conduct research for commercial gain, universities may be induced to shift to more applied research and to restrict the disclosure of their research findings. Ziman (1996) asks another question related to the controversial picture of the academic profession, compared to industrial research. The Mertonian approach takes for granted that academics are altruistic people not pursuing monetary gains. The pursuit of knowledge is of value in itself. The notion of a truly objective, disinterested seeker of truth, is not however consistent with real social practice (Ziman 1996; Calvert 2002). Giving strong autonomy to science as a vital element in order to obtain validated information was also emphasised by Polanyi (1962). In his paper "The Republic of Science" Polanyi warned against external corrupting intrusions and distractions, saying that "any attempt at guiding scientific research towards a purpose other than its own is an attempt to deflect it from the advancement of science" (p. 62).

Merton posited the normative structure of science in 1942 and strengthened the ideology of "pure science." His emphasis on universalism and skepticism was a response to a particular historical situation, the need to defend science from corruption by the Nazi doctrine of a racial basis for science and from Lysenko's attack on genetics in the Soviet Union. Merton's formulation of a set of norms to protect the free space of science was accepted as the basis for an empirical sociology of science for many years (Leydesdorff & Etzkowitz 2001). Some characteristics and beliefs of the academic norms and idealised concept of science still live on in the lives of contemporary academics and practitioners of science. One reason why this view of the social contract of science was dominant for such a long time is that Merton was providing an explicit "common-sense" account of science. The most that scientists will say nowadays is that science is a body of knowledge "regulated" by certain general principles (Ziman 1996). Despite its limitations, the Mertonian approach is a valuable tool to assess the cultural peculiarities of academic research, within the larger R&D system. It not only lays bare the cultural conditions under which university-industry interaction takes place, but also helps to identify the potential conflicts of interest between the academic and industrial parties, as well as the internal normative conflicts.

2.2 The economic rationale

Recent years have seen fundamental changes in the ways the innovation processes are conceptualised. Based on a number of empirical studies and conceptual reasoning, scholars proposed a new understanding of the linkages between science, technology and the economy and, in particular, the contribution of academic research to economic growth and welfare. This new paradigm can be called the "post-industrial paradigm", reflecting the ideas of Daniel Bell (1973). He was one of the first to address the differences existing between the industrial and the post-industrial (or knowledge) society. His argument was that societies are moving to a post-industrial[1] society, where higher education and theoretical knowledge are of greater importance for development.

[1] In some literature, post-industrial society is equated with "knowledge society". I use the term *post-industrial* rather than knowledge society because the latter is still vague and its interpretation may give false implications of the content of the term.

Following the above line of thought, this chapter addresses the economic rationale for science. It starts by looking at the driving forces behind the growing economic pressures for universities. Thereafter, it explains the conceptions of the relationship between science, technology and innovation. The economic rationale is important to understand the industry's behaviour and the growing importance of scientific research as the source of new knowledge for economy and industry's innovation activities. It also helps to understand to what extent the measures intended to facilitate the interaction with universities and industry correspond to real needs.

2.2.1 The driving forces

The importance of new knowledge for economic development has been widely recognised. As early as the seventeenth century, Francis Bacon was the first man to come up with an economic justification as to why society should fund learning and scientific research. He observed that "for knowledge itself is power". It was, however, only from World War II onwards that policy interventions towards harnessing science for utilitarian purposes took on a decided, organised and institutionalised form. Looking back at the developments of the 1980s, it is possible to uncover several interrelated structural and societal changes that have accompanied the increasing public and industrial collaboration in research and development.

Intensified economic competition. Since the late 1980s new market-economy players have emerged in Asia, Eastern Europe, Latin America and elsewhere. With regard to financial services, the advances in telecommunications in the 1980s made generating, processing and storing information possible. The global trade and marketing of high technology goods and services have increased the global competition (Castells 1993; Thrift 1987).

Emergence and development of new technologies. The post-industrial economy is accompanied by rapid technological development and, in particular, information technologies, which have made possible new products and processes in the fields of biotechnology, material technology and nanotechnology. These fields are said to be particularly dynamic, as new knowledge emerges all the time. Consequently, in the 1980s, a variety of interdisciplinary centres and

departments were developed in biology, materials science, optical science and cognitive science (Geuna 1997; Martin 2003).

Growing importance of scientific and technological knowledge. Increasing global competition and technological change have forced companies to conduct research covering a portfolio of technologies wider than can possibly be managed alone. Companies are increasingly trying to keep up with the vast amount of research being conducted, so that they do not find themselves locked into using outmoded products and processes (Lambert 2002; Griliches 1986). Firms are moving away from a system in which most of their research and development (R&D) was done in their own laboratories, preferably in secrecy, to one in which they are actively seeking to collaborate with others. In order to be innovative, companies are increasingly locating some of their R&D operations away from their home country and close to a major source of new knowledge.

Constrained public funding. Governments, especially in western countries, have been experiencing significant public expenditure constraints as they attempt to balance their budgets. In research and development, several policies aim at concentrating research funds more selectively to ensure a higher level of accountability and cost reductions. Overall public research budgets have been subject to considerable stringency. Fields deemed to be of strategic importance for future industrial growth have received increasing funding in the last decades (Faulkner & Senker 1995).

Potential commercial value of academic research. The recognition of the potential economic value of academic research pushed government policies to promote university-industry links (Geuna 1997; Louis & Anderson 1998) and encourage academics to commercialise their research. Under these conditions, the role of universities and the autonomy of science have become less clear (Ziman 1994). It has also been suggested that research and innovation across industrialised countries is characterised by more co-operation, intensified networking and increasing interdisciplinarity (Gibbons et al. 1994).

2.2.2 The relationship between science, technology and innovation

In his famous report, "Science: The Endless Frontier", Vannevar Bush (1945) laid down the principle for the new social contract of science that held sway for most of the second half of the twentieth century. *The linear model*, beginning with basic research, leading to applied research, technological development and finally innovation, gave a new framework for supporting science. Such a concept grew from the successful scientific discoveries and several applications of science during World War Two. The framework was, in particular, characterised by the ideal of pure inquiry in Western scientific philosophy and Humboltian university ideology, with mutual benefits between teaching and research and a high reliance on state funding and on the autonomy of academics and institutions.

According to the linear model, public funding for basic research is justified because it expands the scientific information available to firms and these, in turn, build upon it in their innovation activities. Further theoretical support for this model, and hence the justification for the government to fund basic research, was provided by the work of Richard Nelson (1959) and Kenneth Arrow (1962). Their concept of *market failure* is based on the assumption that a purely market relationship should hypothetically produce the social optimum and that government policy should be limited to re-addressing situations where market failures have developed. The theory holds that scientific knowledge is a uniformly available public good that can be transferred and learnt at little cost. Conversely, limited appropriability, financial market failure, external benefits to the production of knowledge, and other factors suggest that inventors cannot appropriate the returns to their innovations because rivals imitate the innovation. This in turn is likely to lead to under-investment by firms in basic research and to innovative activities. Knowledge, it is said, may spill over from first-movers and innovating firms. Other firms will then free ride on the efforts of the innovators (Metcalfe 1995; Metcalfe & Georghiou 1997). Innovating firms are therefore incapable of absorbing all the benefits that arise from their innovative activity. Such lack of appropriability justifies public intervention to promote innovative activity. Governments may thus directly engage in the production of knowledge and allow its free use, or they may encourage private companies to collaborate in R&D (Mowery 1994).

Little by little the linear model influenced the governments of most industrialised countries and was adopted, thus leading to increased government funding for basic scientific research and a greater involvement of scientists in government actions (Salomon 1977; Martin 2003). However, Bush's framework for science and technology policy and the linear model began to falter soon after its launch – not least due to fast technological development. Even though it has become a less prominent model of knowledge production in universities, it has not wholly lost its explanatory power. It may still apply to some fields of technology (for instance pharmaceuticals). Because of the simplicity of the linear model many still rely on its explanatory power. The argument that science should be left to scientists alone still seems to live on in the lives of scientists, for instance in the manifestation of the tensions and controversies of universities involvement in the commercialisation of research results.

In the late 1960s and early 1970s, a new understanding of the contribution of academic research to technological development emerged. It became apparent that the linear model was inadequate to characterise the relationship between science, technology and the economy. Critics of the linear model pointed to the numerous occasions – not least the advent of the steam engine – when technology appears to have led science (e.g. Layton 1988). Few scholars today would support the purely traditional market failure theory, although it may be used as a general justification for government actions in R&D. The main shortcoming of this model is that the idea of perfectly competitive markets is not considered a realistic description of market behaviour. In addition, one of the basic weaknesses of the theory is that it makes too strong assumptions about government's ability to design policies to rectify some identified market failures (see Ministry of Trade and Industry 2003). From the viewpoint of university-industry collaboration, the market failure approach neglects two broad issues. It does not address how science contributes to technology, nor does it tackle the knowledge demand of different types of firms. As the transmission and utilisation of existing knowledge is costly, to what extent are various types of firms capable of acquiring new knowledge?

A chain-linked model of innovation (Kline & Rosenberg 1986) and *a systemic view* (Dodgson & Rothwell 1994) have been proposed as alternatives to the linear model of innovation. A new understanding of innovation rejects the idea that innovation simply flows out of some earlier process of scientific and

technological discovery. Most recent research sees innovation as an interactive social process, which integrates market opportunities with the design, financial and engineering capabilities of firms. Innovation processes are characterised by continuous feedback between the activities, rather than linear transitions. Furthermore, firms do not innovate alone but with other firms, universities etc. When science is involved in design development, the accumulated stock forms a small part of the whole. In contrast to the linear model science is not seen as the initiator of change, but most innovations are carried out with the available knowledge and learning that occur within production. Only if the existing expertise fails to supply the knowledge needed is there a need for scientific research.

Some recent literature has focused on sectoral differences existing with respect to innovation failure and intervention models (e.g. Pavitt 1984; Breschi & Malerba 1997). For instance, Martin and Scott (2000) argue that the forces leading to private underinvestment in innovation differ from sector to sector across the economy, and policy design should take these differences into account. For instance, industries differ in terms of the mix of basic and applied knowledge that contributes to their knowledge base, in the degree of appropriability of their technology, in the extent to which commercially applicable knowledge is tacit, and in the importance of complementary assets to the commercialisation of knowledge. Thus the nature of the main mode of innovation has implications for the most important sources of sectoral innovation, their failure, and, consequently, for the most effective form of public support for private innovation. They also call for a long-term institutional framework for the support of basic research:

> "The prevalence of innovation market failure and underinvestment in technology implies the need to establish a long-term institutional framework for the support of basic research, generic-enabling research, and commercialisation. The extent to which support should be directed to each area will vary with the sources of sectoral innovation market failure." (Ibid. 2000.)

The core focus of this approach is how universities can provide such knowledge that helps companies to build a set of technological competencies and capabilities as well as enable them to create distinctive areas of competitive advantage.

2.2.3 Economic benefits associated with academic research

Despite the wide consensus on the importance of in-house corporate research, including basic research (Rosenberg 1990), little consensus has emerged as to the extent or nature of the processes by which scientific and technological knowledge drive industrial competitiveness and economic growth. Gibbons and Johnston (1974), de Solla Price (1984), Rosenberg and Nelson (1994) and Klevorick et al. (1994) were among the first to identify the role of academic research in technological advance, beyond the linear model. Their main conception of the innovation process is that public research will sometimes lead technology. More typically it is downstream research and development, or client input, that provides the impetus for industrial R&D projects. Rosenberg and Nelson (1994, p. 341), in their pioneering work on American universities and their role in innovation, argue that "university research most often stimulates and enhances the power of R&D done in industry, rather than providing a substitute for it".

Edwin Mansfield's pioneering efforts in the early 1990s in empirically quantifying the economic benefits of academic research have also been influential in providing support for government funding for basic research. Mansfield surveyed 76 large firms in seven American manufacturing industries to see how many of their products and process innovations introduced between 1975 and 1985 benefited from academic science (Mansfield 1991). In his paper entitled "Academic research and industrial innovation" (1991), his key finding is that, on average, 11% of the new products could not have been developed without recent academic research. The variation between industries was substantial, ranging from as low as 1% in the oil industry to 27% in the drug industry.

Henderson et al. (1998, p. 126) studied universities' patenting activity. They found that the bulk of the economic benefits of university research come from inventions in the private sector that build upon the scientific and engineering base created by university research, rather than from commercial inventions generated directly by universities. Further evidence on the contribution of academic research to industrial innovation is provided by the Carnegie Mellon Survey conducted by Cohen et al. (2003). They observed that, overall, public research played a slightly more important role as a knowledge source for R&D

project completion rather than for project initiation. This suggests that public research provides the means to achieve some technological goals, while the origin of the project idea comes from the firm's own R&D or from clients. The pharmaceutical industry, however, is distinctive in the degree to which public research suggests new R&D projects and contributes to R&D project completion. The findings also suggest that public research plays a less important role as a knowledge source than a number of other sources (e.g. competitors, contract R&D firms, joint or co-operative ventures).

Recent evidence emphasises training, tacit knowledge and indirect benefits, rather than codified information (or even products) as the main output of academic research (e.g. Dosi 1988; Lundvall 1992; Senker 1995; Blind & Grupp 1999; Pavitt 1991, 1998; Salter & Martin 2001; Faulkner & Senker 1994). For instance, Pavitt (1998, p. 797) argues that:

"…the main practical benefits of academic research are not easily transmissible information, ideas and discoveries available on equal terms to anyone in the world. Instead, they are various elements of problem-solving capacity, involving the transmission of often tacit (i.e., non-codifiable) knowledge through personal mobility and face-to-face contacts. The benefits therefore tend to be geographically and linguistically localised."

Academic and business research is often seen as an overlapping and interacting system, with the former augmenting the capacity of the latter to solve an increasing range of complex problems. Networking is used to access tacit knowledge related to both existing knowledge and new knowledge generated by research. Most often the translation of research into practical applications depends on tacit skills and capabilities, whereby knowledge is passed from person to person, not through written codified information, but through experimental learning (Lundvall 1992; Faulkner & Senker 1994, 1995). Therefore, the indirect benefits resulting from training and from unplanned discoveries may be economically more considerable than the benefits resulting from formal networking and commercialisation.

Salter and Martin (2001) distinguish six essentially different types of contribution that publicly funded research makes to economic growth. These are

1. increasing the stock of knowledge

2. training skilled graduates
3. creating new scientific instrumentation and methodologies
4. forming networks and stimulating social interaction
5. increasing the capacity for scientific and technological problem-solving
6. creating new firms.

The first items listed have been emphasised by policy makers since the early days of the post-war period. As Salter and Martin (Ibid. 2001) themselves state: "these benefits are often subtle, heterogeneous, difficult to track or measure and mostly indirect". In Finland, Nieminen's and Kaukonen's (2001) study supports the view that the major benefits of university-industry co-operation are in the areas of generic knowledge, even though product development-oriented co-operation is the most usual reason for co-operating.

The above typology provides a general account of the various benefits of academic research, but tells little about the nature of the relationship itself. It is said that the nature of the relationship between university and industry varies considerably in different scientific fields, technologies and industries (Faulkner & Senker 1994; Rappert et al. 1999). For instance, formal linkages in terms of R&D contracts and literature scanning are relatively more important in biotechnology and related fields, whereas in computing sciences, informal linkages and personal contacts matter more (Faulkner & Senker 1994; Meyer-Kraemer & Schmoch 1998). Schartinger et al. (2002) have found that the intensity of knowledge interactions does not follow a simple sectoral pattern. Rather, the various sectors of economic activity and fields of science engage in different types of interaction. Restricting the analysis of university-industry relations to only a few types of channels may therefore produce misleading and distorted findings.

Faced with increasing competition and shorter development times, there is a growing tendency among firms to redirect the goals of basic research and narrow their focus towards strategic research and applied research with shorter time-horizons (Tijssen 2003). Consequently, firms are most likely to minimise their research costs by outsourcing rather than conducting in-house research. Science-intensive companies are increasingly forced to establish stronger informal and formal linkages with public sector research organisations, and industry now largely rely on universities and research institutes to explore new avenues of

research for the generation of new knowledge (Meyer-Kramer & Schmoch 1998). OECD data confirms this trend, indicating that larger shares of corporate funding for basic research are being spent on joint ventures with external research partners, especially within the local or domestic university sector (OECD 2000).

2.3 The societal rationale

Several observers suggest that a new governance of science is in the process of evolving (Geuna et al. 2003; Nowotny et al. 2001). The forms, mechanisms and content of this new governance of science are however not yet known. New forms of networking and incentives are being developed to reward scientific work. A new cross-national movement is also paying attention to a more multi-dimensional and complex framework for policy discussion (Häyrinen-Alestalo & Kallerud 2004, p. 10) in this respect. Bernal (1939) already recognised the increasing possibilities of developing scientific knowledge that is applicable within society, thus reflecting the idea of enlightenment about societal progress. Science, as a kind of progressive force, is seen as a resource driving a knowledge-based economy.

The economic-growth-driven frameworks are now being replaced by richer accounts. The increasing unbalance between investments in the knowledge-based economy and public services indicates a need to discuss and re-evaluate the effects of one-dimensional strategies (Häyrinen-Alestalo & Kallerud 2004, p. 11). The recovery of the knowledge-based society entails that broad concerns, such as health, social cohesion and sustainable development will be integrated in political orientation. The new social contract requires not just accountability and post-hoc evaluation, but some consideration of societal needs when public funds are initially being allocated to research (MacLean et al. 1998; Cozzens 1994).

Nowotny et al. (2001) argue that we are moving beyond a merely reliable knowledge and towards a socially more robust knowledge. They are not denying that the basic conditions and processes that have been underpinning the production of reliable knowledge are necessarily compromised. Rather, reliable knowledge, as validated in its disciplinary context, is no longer self-sufficient or self-referential once its deliverables are contested or refused. A larger

community insists that its voice should be heard and that some of its claims are as valid, on democratic grounds, as those of more circumscribed scientific communities (p. 155). Grundman and Stehr (2003) have postulated that while current research policy takes the aims of innovations as largely unproblematic (insofar as they help improving national competitiveness), knowledge policy tries to govern (regulate, control, restrict, or even forbid) the production of knowledge. The latter policy view is therefore aware of side effects of new knowledge and tries to address them.

Under this revised social contract, it is expected that, in return for public funds, scientists and universities should address the needs of users in the economy and society, and not only the demands for autonomy. Consequently, universities have also become subject to much more explicit accountability for the money they receive (Geuna 1997; Martin 2003). Higher priority is being given to user involvement, and universities are being invited to extract more revenue for licensing their intellectual property (Pavitt 2001; Goldfarb & Henrekson 2003). The social responsibility theory (Bok 1982, 1993; Geiger 1993) provides also counter-arguments to the utilitarian view of university behaviour. It departs from the idea that non-profit organisations, such as universities, are presumed to serve their clients: students, government, and the larger public interest. Universities have the social responsibility for national imperatives. Unlike business institutions they do not have stockholders claiming the surplus generated by the organisation but they do have social responsibility. Stakeholders with interests in the output of research are now beginning the process of networking with the science base, requiring research to take their wishes into account. A powerful example of the tensions in the existing governance system is Callon's (2003) description of the emergence of alternative and competing claims to the social legitimacy of research findings. He argues that the public is no longer simply willing to "trust the experts". Scientists are encouraged to leave their ivory tower and to pay attention to social problems.

Following a societal rationale for government support for university, the European Union (EU) has, for instance, placed more emphasis upon broader social objectives in the Fifth and Sixth EU Framework programmes. This implies the need to deal with a broader range of stakeholders and to measure the effects of R&D on employment, health, quality of life and the environment (Georghiou & Roessner 2000; Uotila et al. 2004). Furthermore, in most

industrialised countries, the support for basic research is declining and research funding is increasingly concentrated on promoting networks among firms and public research organisations.

2.3.1 Pasteur's Quadrant: use-inspired basic research

In search for alternatives to the linear model and the one-sided economic approach, Donald Stokes (1997) introduces a two-dimensional conceptual framework, the *Pasteur's Quadrant*. In this model, the vertical axis represents to what degree research seeks the frontiers of fundamental understanding, whereas the horizontal axis shows the degree to which the research is guided by consideration of use. This dual dichotomy is exhibited as a fourfold table with quadrants. (See Figure 1.)

Stokes argues that scientific and practical interests are not dispensable and that "scientific research cannot be the traditional one-way model linking basic science and technological innovation needs to be displaced by an image that conceives their dual, upward trajectories as interactive but semiautonomous" (p. 87).

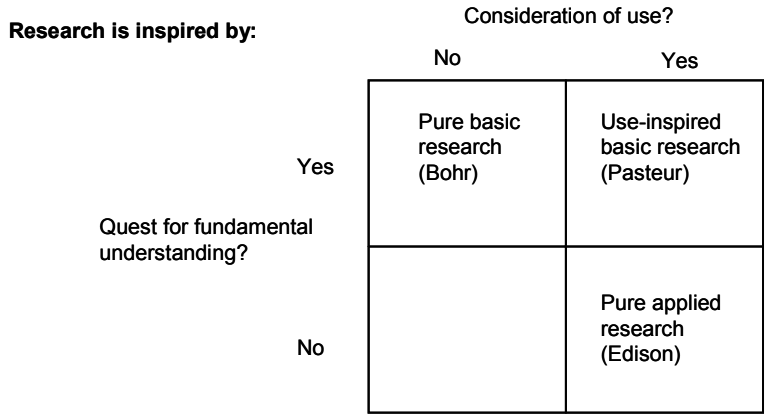

Figure 1. Quadrant Model of Scientific Research (Stokes 1997, p. 73).

The coexistence between basic and applied research is not a new phenomenon. The university system has been the locus of both basic and applied research through most of its history, even at the height of the post-war period. Thus, a new understanding of the linkages between research and technological

innovation, in contrast to the simple linear model, is required. He suggests a new two-dimensional conceptual framework where many degrees to commitment to seek fundamental understanding and consideration of use may exist. Pasteur's work is used to illuminate a paradigmatic example of "use-inspired" basic research. This type of research seeks to extend the frontiers of understanding but is inspired by consideration of use.

Stokes does not deny the importance of the intrinsic scientific advancement. He simply reckons that, despite the innumerable plea for the ideal of pure inquiry and more autonomy, these ideals do not offer powerful arguments for the public support of basic science. On the contrary, Stokes sees that the societal value of use-inspired research within a scientific field may strengthen the case for supporting basic research on which the development of the field is partly dependent. Further, he considers that the decision to proceed with "use-inspired" basic research requires strengthening the process of bringing together two quite diverse kinds of judgements – scientific judgements of research promise and political judgement of societal need. (Ibid. 1998.)

Miettinen (2003) argues that the idea of use-inspired basic research can be seen as a historical hypothesis and interpreted in two ways. Technology has either become an essential force of scientific advancement or the interaction between the two realms has been neglected in the history of science even if this relation has always existed. From an analytical viewpoint, Stokes' conception being intertwined from theoretical understanding and practical use challenges the contemporary view of interaction between science and technology. It also suggests that this interaction can at best serve the academic, societal and economic needs. In contrast, the recognition of the new configuration between science and society does not need to rule out the growing external interest in university research. Nor it does take for granted the ideal of pure inquiry, as the only objective of academic institution or conversely that academia is a uniform unit. It is rather a mix of individuals and variable interests. On the one hand, Stokes' model is concerned with the co-existence of multiple objectives of research. On the other hand, it downplays the extent to which these roles are conditioned by the institutional arrangements and cultural environments of the national (and regional) innovation systems (see also Häyrinen-Alestalo & Peltola 2004).

The present study seeks to further develop Stokes' model of the dual relationship between basic science and technological innovation. Using this framework as a heuristic framework in analysing the duality of research, it helps to identify the objectives that are visible in the attitudes of academics and university responses concerning market demand. Moreover, the model can provide a methodological basis through which it is possible to explore various external demands and expectations towards universities.

2.4 Towards an integrated contract of science

2.4.1 Transformation of universities

The current debate on the changing nature of universities and knowledge production is strongly influenced by the economic rationale. The Mode 2 of knowledge production (Gibbons et al. 1994) has perhaps been one of the most referred to and debated concepts of the 1990s in explaining the university transition. Gibbons et al (1994) argue that we are witnessing a shift from a disciplinary, primarily cognitive context (Mode 1) to a broader interdisciplinary social and economic context (Mode 2). Knowledge is increasingly being produced in "the context of application", which requires a process of continuous negotiation of needs, interests and specifications of all the involved actors (including government) (Jacob 1997, p. 38). Still, Mode 2 of knowledge production is enlarging the number of agents involved in research and widening what is considered and defined as research. Consequently it changes the position of established institutions, disciplines and research practices (Martin 2003; Owen-Smith & Powell 2001). Finally, compared to the internal scientific peer review of Mode 1 research, Mode 2 implies social responsibility and accountability with a broader set of social interests acting as new quality control criteria (Gibbons et al. 1994).

> Scientific and technological knowledge is being produced in new ways … the familiar discipline-based, internally driven, individually-dominated structures that currently dominate the universities and the public sector laboratories are yielding to practically oriented, transdisciplinary, networking-dominated, flexible structures that are characteristics of the mode of organisation of science and technology in the most advanced sectors. (Gibbons et al. 1994, p. 79.)

It has been widely debated whether or not the transition from traditional Mode 1 to Mode 2 knowledge production has actually taken place in practice. Not least because of the lack of systematic empirical evidence (Weingart 1997; Godin 1998; Martin 2003) and because the changes that happened in knowledge production are neither regarded as radical nor new (Hicks & Katz 1996; Etzkowitz et al. 1998, p.43). Some scholars emphasise that Mode 1 and Mode 2 of knowledge production are co-existing, co-evolving and complementary (Llerena & Meyer-Krahmer 2003; Martin & Etzkowitz 2001; Martin 2003). The Mode 2 way of thinking also attracts criticism because it simplifies the developments that have occurred in the relationship between science and society, and because of its too broad scope and unsuitability for analytical purposes (Tuunainen 2002; Nieminen & Kaukonen 2001). The model is not able to represent the actual research dynamics, where conflicting interests and objectives are negotiated. The Mode 2 thesis tends to downplay the extent to which these changes are taking place within the different institutional and cultural environments, as well as different configurations of university behaviours. Some critics say that Mode 2 is preferred by policymakers because of the added legitimacy to make science more effective (Häyrinen-Alestalo 1999; Jacob et al. 2003). The Mode 2 research conceptionseem to neglect the fact that while universities develop many different types of knowledge (embodied in ideas, inventions, artefacts, articles and individuals), it is the firms that have the comparative advantage to "make aeroplanes", "design microprocessors", or otherwise produce goods and provide services (Nelson 1990). In emphasising the economic significance of academic research, the Mode 2 conception fails to capture the social values influencing the conduct of research. It would therefore be misleading to say that all of these purposes can be served in equal measure by all universities (or disciplines), nor can it be supposed that individuals can or need to contribute to these goals.

Closely associated with the Mode 2 approach, *The Triple Helix of university-industry-government relations* (Etzkowitz & Leydesdorff 1997; Leydesdorff 2000) postulates the emergence of a new institutional order. Three institutional spheres (university–industry–government) are increasingly interwoven through a spiral pattern of linkages, at various stages of the innovation and industrial policy-making process. This view assumes the existence of an imaginary space for knowledge production, where research takes place in a totally deinstitutionalised, fluid, and amorphous environment (Shinn 1999, p. 155;

Miettinen 2002). The notion of "Entrepreneurial University" (Etzkowitz 1989; Clark 1998; Etzkowitz & Webster 1998; Etzkowitz et al. 2000) has also increasingly been used in relation to the spectrum of evolutions faced by academia. The entrepreneurial university encompasses a "third mission" of economic development in addition to research and teaching, and a concept now being referred to universities which possess a wide range of infrastructural support mechanisms for fostering commercial activities and academic entrepreneurship.

Critics (Ziman 1994, 1996; Feller 1990) suggest that entrepreneurial engagement may have damaging effects on free access and exchange of new knowledge as well as on ethics and conditions of scientific research. Conflicts typically result in compromises and normative change, in which research pursues profitable lines of inquiry rather than the advancement of knowledge. The ultimate worry is that, when universities are encouraged to take a more entrepreneurial approach to research, the universities themselves may become too commercially oriented. A potential area of conflict is seen between the openness of scientific research and the competitiveness of the commercial world. Yet, as universities become more commercially engaged, the institutional and normative boundaries between public and private science; science and society; and science and technology become blurred (Rappert et al. 1999; Owen-Smith 2003; Geuna et al. 2003).

An alternative but related characterisation of the changing nature of knowledge production and of universities has been put forward by Slaughter and Leslie (1997). They suggest that the emergence of market like behaviours inside the university is due to the increased competitiveness environment. The competitiveness approach derives, in part, from the resource dependency theory (Pfeffer & Slancik 1978; Pfeffer 1992) and in part from the utility maximisation model (James 1990; Feller 1990; Geiger 1993; Lee 1996). Resource dependency arguments assume that policy changes and decline in the state share of support induce university commercialisation. As research funding becomes increasingly scarce and competitive, academics may not be able to afford to be too selective about non-traditional funding sources and thus turn their attention to new external resources. Aside of teaching and exploring challenging subjects, professors must compete for the grants they need to pursue research and support their students. Many university members earn extra money consulting companies, collecting royalties, giving lectures, or teaching in summer schools. In this atmosphere, the

attraction of research and outside consulting could lead professors to neglect their teaching duties and ignore their students. There is also a fear that institutions will have to shift away from basic research towards more applied oriented science and technology. (Geuna 1997, pp. 24–25.) The economic incentives and constraints that govern the behaviour and decision making of both universities and individual scientists are therefore in central focus.

The resource dependency perspective rests on the assumption that university behaviours can only be understood if actions of external actors are taken into account. Conversely, the utility-maximising theory sees organisations as self-directed, autonomous actors pursuing their own ends, influenced by opportunities and constraints. Further, the utility-maximising theory assumes that unlike business institutions, universities do not have stockholders claiming the surplus, but tend to spend all revenues within the organisation itself. (Ibid. 1997; Slaughter & Leslie 1999, p. 65.)

Both the resource dependence and the utilisation maximising theories lead us to expect that beliefs about the positive personal and professional outcomes of university commercialisation may vary among administrative staff, faculty members and policy-makers. University administrative staff would seek to maximise resources that contribute to their research profiles and meet national economic priorities. Departmental heads seek to develop reliable and predictable resources streams to support their centres' work, and to obtain financial incentives to patent or disclosure. Faculty members instead may engage in commercialisation if it enables them freedom and independence and attracts more resources. Furthermore, perceptions may change as researchers move up the career ladder or if career opportunities increase. Yet, the distinctive institutional environment in which commercial activities are embedded will influence the researcher's perceptions of the simultaneous pursuit of basic research and commercial science. (Geuna 1997.) However, the goals of scientists, administrators and other faculty members may be different and sometimes even conflicting (Geuna 1997; Slaughter & Leslie 1997). Moreover, utilitarian sciences (e.g. natural science) and less marketable disciplines (e.g. humanities and social sciences) are not equal with respect to commercial value, and have different incentives and preference profiles.

Although prior research on the role of universities in commercialisation has done much to reveal the changing role of universities in creation, dissemination and utilisation of research, no theoretical approach on its own is adequate to understand the dynamics of university behaviour. The existing approaches such as Mode 2 thesis or Triple Helix seem to emphasise economic determinants influencing university behaviour downplaying academic or societal developments. Further, these approaches do not seek to analyse the diversity in university-industry collaboration nor they they take attention to possible counterforces in the academic community. All university scientists are neither willing nor capable to move on commercial research arena.

Viewed from various theoretical perspectives, universities are not only a source of knowledge and competence, but they themselves increasingly become practitioners in the actual process of knowledge transfer and utilisation and dissemination of research results. Moreover, what is to be counted as acceptable scientific activity, and thereof university behaviour, seem to be revisable. Furthermore, the boundaries are liable to revision as these situations change. Various criteria can legitimate the separation science from other activities. Therefore, the boundaries between science, technology and innovation need to be understood in relation to the contingencies of particular historical situations. In fact, scientific knowledge is a community affair as well as the outcome of a complex process of social negotiation.

2.4.2 An interpretative framework

It is clear that neither any single field of research nor earlier models such as Mode 2 or Triple Helix alone has succeeded in explaining the ongoing changes in the university system. The present study attempts to integrate the academic, economic and societal perspectives related to the academic research culture and the role of science in innovative activities of firms and society in order to construct a systematic conceptual framework to explain the emerging entrepreneurial role of university. Especially through the academic and economic rationales it is possible to obtain a better understanding of both internal and external factors affecting the university engagement in entrepreneurial activities. The main characteristics of the various rationales for governance of science are illustrated in Table 1.

Table 1. Academic, economic and societal perspectives on science.

	Academic perspective	**Economic perspective**	**Societal perspective**
Rationale for public intervention	Scientific advancement Basic and applied research	Economic growth Industrial and technological competitiveness	Social welfare Sustainable global competitiveness
Role of the state	Identification of priority areas in the field of science and technology	Steering technology transfer and development through funding mechanisms	Decision making over R&D priorities with actors of NIS
Role of scientific research in innovation	Source of new ideas, skills and knowledge	Supply and dissemination of new knowledge and technology, monitoring the development, instrumentation	Knowledge producers and transmitters
Boundary between science, technology and innovation	Asymmetric relationship between science, technology and innovation	Science and technology overlaps but are driven by different forces	Symmetrical, interpenetrating systems, no intrinsic qualitative differences
Model of R&D and innovation	Linear	Chain-linked, systemic	Systemic, interactive, recursive
University-industry interaction	Skilled labour force for industry Separate researchers and labs	Formal networking Commercialisation of research results, New science-based companies	Teamwork
Theoretical roots and typical exponents	Neo-classical economics, Functionalism Merton, Bush, Polanyi	Evolutionary economics, New economics of science Kline & Rosenberg 1986; Dasgupta & David 1994; Mansfield 1991; Etzkowitz & Leydesdorff 1997; Gibbons et al. 1994	New growth theories, political sciences, a cross-disciplinary perspective in economics, engineering, management, sociology and history Stokes 1997; Nowotny 2001; Callon 2003

The academic rationale for science emphasises that the social context of science is distinctive and constitutive compared to the non-scientific world. This view is seen as the most influential within discipline-based basic research, from the post-war time until the 1980s. It arises from the tradition of the sociology of science, which closely refers to the themes of socialisation, interaction and exchange, organisation, cognition and cognitive change. As viewed from the academic perspective, science is an activity which depends on its practitioners being open-minded, impartial and socially neutral (Mulkay 1976). This conception of science is based upon the belief that the pursuit of knowledge is of value in itself, and that only very knowledgeable people can be trusted to pursue it effectively (see also Ziman 1996). Indeed, the scientific profession possesses considerable cognitive authority.

The academic configuration of scientific research has several implications for the role of science in society. First, it implies a high degree of autonomy for the realm of science, which was reinforced by the "boundary work" of the scientific community itself, as Merton and his successors claimed. It privileges the role of the universities and other public research organisations as the principal environments for conducting scientific research. Finally, it assumes a separation between the sphere of science and those of technology, politics and economics. This rationale pays attention to the differences among the various research communities, norms and customs governing the production of knowledge as well as to the members of the various research communities. Little effort is directed to exploring the processes of production, dissemination, and use of knowledge. Furthermore, it says little about the researchers' potential motivation to engage in entrepreneurial activity.

From the academic perspective, three questions deserve attention in this study. Firstly, how to promote greater returns from public investment in academic research, without undermining the scientific values and autonomy of academia. This relates to the question of how to carry out basic functions successfully, and how to ensure the advancement of science and the disclosure of research. Based on recent discussions, it seems that many Finnish universities and academics are reconsidering their role in society, as well as the importance and necessity of ensuring the autonomy of academic research. Secondly, to what extent is science a cognitive system in its own right? Can the functions of universities be replaced by other organisations? Thirdly, are academics pursuing scientific reputation in

the traditional sense (in order to receive communal recognition), or are they assuming new social norms, which allow them to benefit from the commercial returns of research and legitimise their behaviour? These questions will be addressed in Chapter 5, by carrying out an empirical analysis of university responses to their growing entrepreneurial role.

The economic rationale for science has been dominant from the 1980s with an emphasis on technological development. It sees universities being called upon to develop a closer and more instrumental role in advancing industrial competitiveness and innovation. Science and technology overlap but are driven by different forces. Furthermore, it is viewed that science is too important to be left to scientists who may possess an increasing desire to influence the agenda and prioritise scientific research. The economic perspective for university-industry collaboration calls for a new configuration of research, where scientists are engaged in commercial activities such as technology transfer and identification of business potentiality and patenting.

Universities and public research organisations make a significant knowledge contribution to innovation[2] and this contribution varies across fields, industries and by type of collaborative interaction. In addition, the absorption and utilisation of new knowledge into new artefacts and industrial innovation is a complex social process involving a range of knowledge sources and skills, where most relationships and interactions are neither direct nor obvious (Gibbons & Johnston 1974; Mansfield 1995; Cohen et al. 2003). It is particularly important, in terms of this present study, to analyse the significance, nature and outcomes of university partnerships for firms' innovative activities.

[2] The first attempt to define *innovation* traces back to Schumpeter (1942, 1949), who made a clear distinction between invention, innovation and imitation, as well as process and product innovation. Dosi's (1988) view is broader than Schumpeter's: "In an essential sense, innovation concerns the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new product processes and new organisational set-ups" (p. 222). In brief, here innovation means new products or processes launched on the market or used commercially, as well as the rough sketch or idea of a possible new product or process. The reason for using this wider definition is that those interviewed in the present study did not make a clear distinction between invention and innovation. Therefore, when interviewed, researchers reflected their views on the contribution of their research to innovation and we cannot be sure whether they speak of inventions or commercialised innovations.

Understanding the role of universities within knowledge production is important from the innovation perspective in particular. Innovations are rarely developed by a single actor. The overwhelming majority of innovations are currently developed in some kind of collaboration, irrespective of industry and firm size (Palmberg 2001). Thus, the competence and know-how of universities may represent a crucial input for the innovation process. Apart from the knowledge input, collaborations with universities may provide linkages to wider domestic and international innovation-related networks, especially for more peripherally located firms.

Despite the great research interest devoted to networking between science and industry, a number of questions remain open. For instance, to what extent do scientists regard collaboration with industry as instrumental to gain access to research funding and to ensure continuity of research? Or do scientists genuinely aim to contribute to the economic targets of industry? What role does long-term networking and trust play in obtaining research and commercial objectives? More information is needed on the intertwining objectives of each research partner and collaboration constraints. Furthermore, under which circumstances is this interaction reciprocal, i.e. when can all parties benefit from this relationship? Finally, does the interaction between academics and entrepreneurs result in greater benefits than those that could be achieved by working in isolation? The issue of additionality of collaboration for both universities and firms is therefore essential.

Especially the Mode 2 thesis provides a valuable tool when it comes to analysing the characteristics of increasing networking, interdisciplinarity and the need for societal accountability, all inherent to the EU projects. Effective measures for the promotion of the diffusion of knowledge should rest upon a clear picture of the ways in which universities generate, distribute and exploit knowledge. Understanding the social norms of science, economic and societal incentives that govern university behaviour is essential for decision-making. In the present study, networking and interdisciplinary work will be addressed in three respects. Firstly, the extent to which networking and interdisciplinarity can be seen as a part of an entrepreneurial activity and of the characteristics of an entrepreneurial university. Secondly, the way in which Finnish university institutions have moved towards the networking and interdisciplinary research mode. Thirdly, the

major implications of the increased networking and interdisciplinarity on the structure and culture of the university.

Under the economic rationale, the competitiveness approach can represent a useful framework to address the path-dependence impact and self-reinforcing mechanisms of entrepreneurial behaviour, where early success feeds the subsequent research or patenting performances leading to either a high or low productivity path.[3] The competitive approach in research is said to cause a shift in university research away from fundamental research. At the same time it is believed that the flow of knowledge among the various sites, most notably university and industry, generate positive knowledge spillovers. Therefore, this approach can be used to analyse potential unintended negative and positive effects that a closer university engagement in commercialisation may produce.

According to *the societal rationale*, the societal dimension of university research becomes essential in the new governance of science. As suggested by Nowotny et al. (2001, p. 11), the society itself, and the institutions and organisations it comprises, are now organised around the availability and manipulation of knowledge. The boundary between science, technology and innovation is seen as symmetrical and interpenetrating without intrinsic qualitative differences. This approach calls for a broader interactive role between the traditional university tasks and society, theory and praxis. Furthermore, the institutional structure of universities has become not only more open but also more responsive to the needs of society. Accordingly, it assumes new forms of activities and organisations, such as hybrid organisations, trans-sectoral and trans-professional communities.

Although the societal role of university is not under scrutiny in the present study, it is important to acknowledge the existence of this role at a theoretical level. The societal perspective is provided to refer to the continuation of the transformation process itself. The societal approach to science is regarded as exploratory, in the sense that it aims to bring some tentative insights and

[3] This is often known as the "Matthew Effect" (Merton 1968), which refers to the development that the organisation and resource allocation structure of science tends to reward successful individuals and groups with access to means that increase their probability of being successful in the future.

arguments into the discussion, especially with respect to the third function of universities, with the aim of identifying topics for further research. At least two features of the societal approach deserve further attention since it signals important changes in the role of universities. First, the continuous calls for greater social relevance of science require a new conceptual framework for explaining the interaction between public and private R&D. This may open new opportunities for practical exploitation of new science-based technologies in areas such as health, security, environment and societal cohesion. Second, it is also attributable to examination of the long-term societal impacts of public R&D. Furthermore, analysis is needed on the short-term and long-term effects of university-industry linkages as well as intended and unintended consequences of this relationship. Such effort could generate a broader multidimensional picture of the role of universities in society.

3. Studying entrepreneurial university

Having identified the principal features of university research behaviour and its role in the creation, dissemination and utilisation of knowledge, how are we to understand the dynamics and nature of the emerging entrepreneurial university? This chapter frames the research questions and introduces the data. The last section further develops a typology that accounts for the various university responses to market and for the entrepreneurial role.

3.1 Research questions and data

According to the Triple Helix Model, the origin of entrepreneurial development can be traced back to academic, industrial and policy settings (Etzkowitz & Leydesdorff 1997). In this study, the entrepreneurial university encompasses university-industry interaction, commercialisation (e.g. custom made education courses, consultancy services, extension activities) and commodification (e.g. patents, licensing, faculty or student owned start-ups). Furthermore, incentives for adjusting lines of study and the allocation of research to the demands in the private and public sectors are also part of entrepreneurial development (Jacob et al. 2003; Henrekson & Rosenberg 2001).

For the purpose of examining the entrepreneurial role of universities, this study analyses the interaction between universities and industry. The starting point is that firms develop innovations and they need their own resources and knowledge to solve problems. If the existing knowledge fails to produce results or solutions, scientific research is needed, and universities can be one source of knowledge. In research collaborations universities may have also other objectives that differ from the firms' objectives. These objectives are related to their core tasks, education and research. Hence, the university-industry interaction is shaped by the internal cognitive dynamics and structures of universities and firms as well as the values and goals held by those involved in the research collaboration. The process is not influenced only by the goals and interests of firms and universities but constrained by financial pressures and opportunities. Moreover, the organisation and values are shaped and affected by the institutional environment in which the collaboration is taking place (Nieminen 2005; Häyrinen-Alestalo et al. 2000). Therefore, in the university-industry interaction, various cognitive,

structural (e.g. institutional and organisational) and interpretive (motivational) dimensions can be identified. For this study, emphasis is placed on investigating the cultural, organisational and institutional characteristics of university-industry interaction. The research questions for the empirical analysis can be formulated from the university, industry and policy perspectives.

From the *university perspective,* the study seeks to answer to the following research questions:

- *How have Finnish universities responded to the challenges posed by the growing utilitarian demands and expectations? What are the major incentives, disincentives and bottlenecks for the establishment of a collaborative linkage between these two sectors? What are the main drawbacks, benefits and tensions deriving from the university-industry linkages and university engagement in commercialisation?*

These questions are analysed at both individual and organisational levels. At an individual level, the study examines the different academic roles and research approaches to market demand adopted by Finnish university researchers. The analysis is grounded to the Stokes model of Pasteur's Quadrant. In doing so, the analysis focuses on the extent that academics are responsive to the entrepreneurial ideology and whether they share the view that scientific research and practical use can be achieved simultaneously.

University responses to market are analysed by drawing on data from three postal surveys sent to Finnish participants involved in the EU framework programmes covering the experiences from the Fourth and Fifth Framework Programmes. These surveys investigate the goals, benefits and problems of research collaboration with firms and commercialising research results as viewed by university researchers. With respect to the difference compared to the previous analyses, the present study analyses the implications of carrying out research projects with and without a collaborative relationship between the university and industry. The limitation of the survey method is that it provides general information on the assessment of commercialisation but not, for instance, about its nature or intensity. Some errors may result from different interpretations of the term 'commercialisation'. For the university respondents the term 'commercialisation of research results' may have a different meaning

including patenting, establishing start-ups, consulting arrangements or collaborations with industry. Respondents covered mainly all the disciplines but natural sciences, technology, medicine and forest and agriculture are better represented than humanities and social sciences. An observation that many results in this study are compatible with other available studies provides a reason to believe that the data accurately describes the developments related to the entrepreneurial role of universities.

The second data set for analysing university responses regarding the entrepreneurial role comprises 78 semi-structured interviews among university leaders and research staff. The aim of the interviews was to obtain details and descriptions of the university responses towards a growing entrepreneurial role in different institutions. The interview data also examined the structural and organisational changes in Finnish universities in the 1990s, highlighting the significance of the research environment in terms of constraining or benefiting entrepreneurial behaviour. The organisational and cultural changes for university structure are analysed in terms of the discipline structure, the research orientation, financing and personnel capacities. The leaders (N=36) were the heads of university departments and research centres, while the research staff included both senior and junior researchers. A detailed description of the data is provided in Appendix 1.

The *firm perspective* is aimed at providing some insights into the universities' contributions to the innovative activities of firms as well as providing some information about the actual needs of the firms' in relation to academic research. From the firms' perspective, the following set of questions will be examined:

- *Which role do the universities play with respect to commercialising research and the innovative activities of firms? What do firms expect from universities and how do universities contribute to technological development and innovation?*

Three surveys generated on the Finnish firms' experiences in the EU framework programmes are intended to provide information on the expectation of firms with regards to universities and the contributions of university research in terms of innovation and commercialisation. A second set of data for the firms' perspective is provided by a survey among 98 Finnish small and medium-sized

enterprises and research based companies, conducted in the autumn of 2002. A detailed description of the data is in Appendix 2 (for further information, see Loikkanen et al. 2002). This data is aimed at providing further information about the barriers and problems that exist in the interaction between universities and SMEs. Interviews with four representatives of small and medium-sized enterprises were conducted in the autumn of 2002. These cases were studied in the Nordic project that identified the state of the art in commercialising academic research in four Nordic countries. The study was intended to be a review of existing research in the area, and therefore little new empirical research was conducted. The cases studies (16 in total) are used first and foremost to obtain an overview of how SMEs themselves perceive the existing policy mechanism and to shed light on whether they perceive public research organisations to be important sources of R&D. The sample size is small but it has not been used as representative of the universal set of SMEs rather as a source of information about specific issues. (For further information, see Jacob et al. 2003.) Special attention is paid to the knowledge demand expressed by small and medium-sized enterprises.

University-industry interaction and commercial utilisation of academic research are affected by the policy framework conditions such as public promotion programmes, interdiary infrastructure, legislation, regulations and institutional settings. The *policy perspective* is adopted to address the wider developments in research conditions and mechanisms intended to foster university engagement in economy. From the *policy perspective,* the following questions are asked:

- *Which role do policy-related framework conditions, including the set of policy programmes and initiatives, legal regulations and infrastructure, play in fostering the entrepreneurial university?*

These questions will be studied by drawing on the existing literature and policy documents related to the fostering university-industry interaction and commercialising academic research in Finland since the late 1970s. Further empirical data is provided by the expert workshop discussing universities' "third function" in the autumn of 2003. The intention of the workshop was to discuss the third function of universities and, especially, the university role in commercialisation. The number of workshop participants was 11 and they represented various areas of expertise.

The choice of the Triple Helix framework as the background format has a number of advantages. Firstly, it puts the study well within the international paragon for this kind of work and secondly, it provides the analyst with a simple framework from which to outline and evaluate the policy initiatives themselves as well as gain insights into the perspectives of the main targeted actors. Studying the questions empirically within the same framework offers the opportunity to assess the internal and external factors affecting the university-industry collaborations[4].

3.2 The quadrant model as an analytical tool

The academic rationale of the university's role with respect to science emphasises two aspects: the production of knowledge and the source of a highly educated labour force. The former is deeply ingrained in the thoughts of many academics. But today, the second interpretation is equally adopted. The new rationale for science emphasises universities as a source of scientific knowledge and research staff, on the one hand, and its responsibility to contribute to societal and economic development on the other. The traditional view of the university researcher as a dedicated and disinterested searcher for truth is thus being replaced by a new model of an academic entrepreneur who balances university responsibilities and corporate activities (Etzkowitz et al. 2000; Häyrinen-Alestalo & Peltola 2004).

[4] *University-industry collaboration (*or *interaction*) in general refers to different types of interaction between the public and private sectors, which are directed at the exchange of knowledge and technology. This includes direct and indirect transfer channels such as personnel (also graduate) mobility, joint research projects, contract research, academic consulting, licensing, prototypes, spin-offs, training for industry researchers, informal contacts (including the use of publications), personal networks, training of students at firms etc. This study focuses particularly on the collaborative research between universities and companies, which is co-funded by businesses and the university or by a public sector body such as a national research funding agency or the EU Commission. In collaborative research, the business and university researchers work together on a shared problem. Collaborative research tends to be more fundamental or pre-competitive in nature than contract research. The contribution of each side to the partnership varies, but the firm may provide long-term secure funding along with firm data, staff and equipment. In return the university department would offer access to skilled researchers and an international network of academics.

The present study further develops a typology that accounts for the various university responses to market and for the entrepreneurial role. The typology applies Stokes' (1997) and others (Owen-Smith & Powell 2001; Stankiewicz 1986) reasoning about the relationship between basic scientific understanding and technological know-how. The typology developed here is based on the conception that the emergence of a new function for university researchers, and a more differentiated university system, is influenced by two interrelated phenomena. First, at the level of research networks and funding processes, the lack of appreciation of industrial partnership, and the belief that university engagement with industry may have a detrimental impact on the universities' autonomy, or may hinder university engagement with industry. Furthermore a conflict over goals set by the academia and the specific needs of the sponsoring organisations may hinder academics from engaging in entrepreneurial activities. This view stresses the importance of academic traditions and values, in particular. Second, the belief that scientific and commercial (or other practical interests) are controversial and cannot be simultaneously achieved, points to the traditional academic conception of science/technology and basic/applied research distinction. The latter highlights the cognitive dimension of the collaborative relationship between universities and industry.

In the present typology, universities' responses are divided into a two by two table depending on the researcher's expressed beliefs concerning the following two dimensions:

(1) The horizontal dimension reflects the cognitive dimension of the university responses on intertwining scientific and technological knowledge. It shows the dichotomous conception of whether there is an emphasis on the quest for fundamental understanding or consideration of use or both.

(2) The vertical dimension reflects the cultural dimension of university responses to utilitarian demands. It shows the dichotomy of whether or not university engagement with industry is regarded as detrimental for universities' autonomy. Figure 3 lays out the possible key lines of agreement and disagreement for the four types of university approaches. It is to be noted that these approaches represent "ideal models" and do not appear as such.

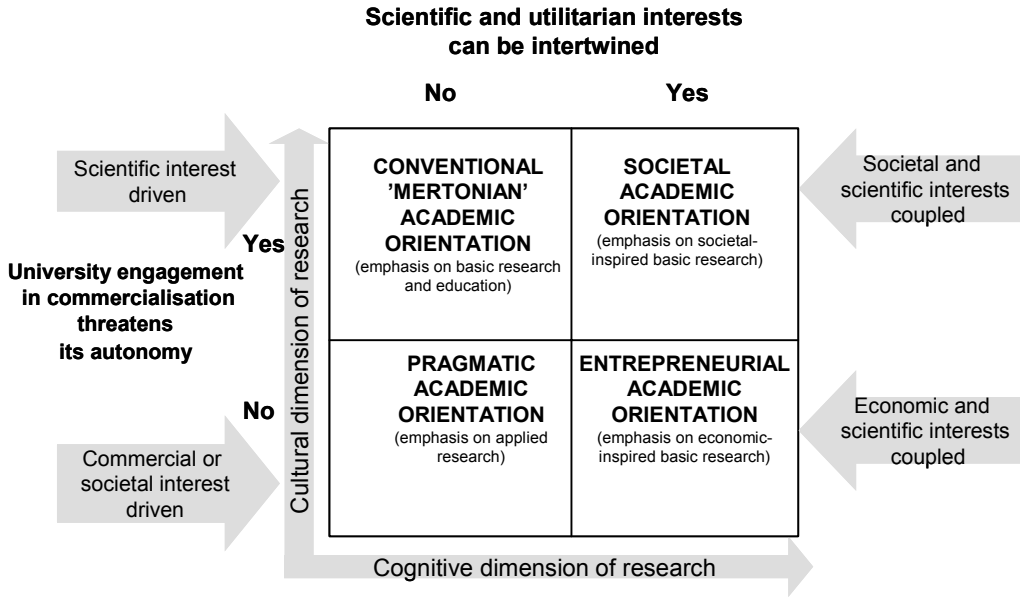

Figure 2. University approaches to market.

In this model, four university approaches to the entrepreneurial and utilitarian demand are identified:

The conventional 'Mertonian' academic orientation reflects the conventional position towards the utilitarian demand, with a strong quest for understanding without consideration of practical use. An academic with this belief tends to think that university and industry have distinctive roles, and is concerned that academic involvement in commercial activities threatens the autonomy of universities. The scientific research is not considered as totally socially neutral but there are no direct links with scientific understanding and its practical use. The academics in this category pursue to maintain their own neutrality and avoid being engaged in commercial activities thus tapping into other financial sources. This approach is built on R.K. Merton's (1973) conception of the norms of science as characterised by universalism, communalism, disinterestedness, and organised scepticism. This academic can be labelled as "Mertonian academic".

The pragmatic academic orientation reflects another approach that sees clear difference between basic and applied research. For the "pragmatist", research is guided by practical goals (commercial or societal) and a profit-making drive. For

him/her the argument that academic science might be threatened by commercialisation is basically irrelevant. These academics represent skilled experts who hold competencies in various arts of science. Most likely these academics work in applied-oriented research organisations and are involved in projects, aiming at testing, experimenting and demonstrating existing theoretical models. They hold a pragmatic view that collaboration with companies leads to have access to external funding sources and to find an exploitation outlet for research capabilities. These academics most likely serve as a source of practical assistance for industrial needs.

The societal academic orientation represents the new approach to the scientific endeavour. The "societally-oriented academic" shares the traditional belief that university engagement in commercial activities may threaten the independence of academia, but agrees that science is undergoing a structural transition, thus becoming a more heterogeneous social institution. An academic of this type shows a great interest in solving problems that have a societal relevance and in providing interesting additional information about the accidental features of an invention.

The entrepreneurial academic orientation represents another type of the new rationale for science. It reflects a research approach that is inspired by the search for understanding as well as economic use. He/she does not view the commercial engagement as detrimental to science. Rather, he/she thinks that economic demand will enrich the scientific endeavour and pose new intellectual challenges for the conduct of academic science. These academics are the most willing to set up their own companies. For both new positions, multi-disciplinary and multi-institutional collaborations are necessary tools in the production of knowledge (Gibbons et al. 1994; Owen-Smith & Powell 2001). This academic could be called the "academic entrepreneur".

Typology of this kind can be regarded as an ideal model illustrating multiple roles and responses of universities toward market demand rather than as a final result. The present typology of university responses to the utilitarian demands enables to shed light on how the technological and societal changes affecting the nature of scientific knowledge are also influencing scientific career patterns. It also allows one to address different strategies that scientists may adopt in order to meet the growing utilitarian pressure and demand as well as to assess how the

scientific, economic and societal goals are balanced. Finally, this framework enables to identify the bottlenecks of the promotion of the utilisation of university research. The study draws on interviews and survey data regarding a sample of Finnish academics, in order to empirically test this typology.

4. Policies fostering entrepreneurial university

The previous chapter of this study discussed some observed implications of university engagement in entrepreneurial activities. While similar changes and effects are evident throughout Europe, their effects and policy response varies from country to country. The formation of connections between actors involved in the national research system is embedded in institutional, legal and cultural traditions, which shape its further development (Senker 2001). University-industry relations also vary according to university and the respective fields of science. Different fields of science meet the needs and requirements of their operational environment with quite different resources, opportunities and qualifications. It is more challenging for researchers with a basic research orientation to find collaborative business partners than it is for researchers from applied or commercial fields (Nieminen & Kaukonen 2001; Nieminen 2005).

Policy development, as well as its implementation, set the contextual framework for the interaction between universities and industry, aiming at the commercialisation of academic research. The present chapter highlights the actions taken in Finland from the late 1980s onwards in order to promote the entrepreneurial role of universities by reviewing policy development. The review begins with a short overview of the recent developments in the Finnish economy and in Finland's science and technology policy. In the following sections, the mechanisms and instruments aiming at promoting interactions between universities and firms (as well as other users of knowledge) and the commercialisation of research will be examined. The analysis of the policy developments and conditions for commercialisation in Finland is based on studies, reports, statistics, documents and the workshop organised in the autumn of 2003. Altogether 11 experts from different organisations (university management, companies, bridging organisations and financing agencies) discussed the "third function" of universities and the commercialisation of academic research.

4.1 Finland's innovation performance and challenges

Recent economic and societal development in Finland has largely built on the development of high technologies and their effective use on increasing exports. This has significantly improved Finland's position in international competition (Rouvinen 2001; Lemola 2002). In many international comparisons Finland has been continuously ranked as one of the leading countries in terms of growth, competitiveness and technological sophistication and infrastructure (e.g. the annual rankings of IMD and World Economic Forum). Finland also ranks well in terms of productivity, tertiary education enrolment, per-capita patenting in high-technology, and business and public spending on R&D (see e.g. European Commission 2003; Statistics Finland 2001, 2004).

Compared to other developed countries, Finland's economic growth has been positive from the mid-1990s onwards. In 1991–1993 the Finnish economy faced major economic depression which was aggravated by the old production and export structure finding itself in open market conditions[5]. The depression was followed by a strong policy response with an essential increase in private and public R&D investments and other activities promoting innovation. This development led to a rapid structural change of the economy towards ICT and related high-tech exports. According to the latest figures, in 2004 the volume of Finland's GDP grew by 3.7 per cent (EU25 2.4%), compared to 2.4% per cent in 2003 (EU25 0.9%). (Oksanen & Kutinlahti 2005.)

Alongside these positive developments, there are issues in which Finland has not performed so well. The standard of living (defined as GDP per capita in Purchasing Power Standards) in Finland is actually lower than what could be predicted. In 2004, Finland's GDP per capita in PPS (Purchasing Power Standards) was 115 compared to EU25 value 100. In 2000 the annual average inflation rate was 3 per cent whereas for EU25 the corresponding figure was 2.4

[5] GDP drop was over 10 percent, 500 000 or 1 in 5 jobs were lost, unemployment rate increased from 3.5 to 16.5 percent, a major banking crisis, central government debt rose from 10 to 70 percent of GDP. The macroeconomic background of the crisis was in badly handled financial liberalisation, major shocks such as the collapse of the Soviet Union, world recession, high European interest rates due to German unification, and also in the not very successful macroeconomic management of the Finnish economy (Vihriälä 2004).

per cent. Nevertheless, in 2004, the inflation rate in Finland was 0.2, which is lower than the EU25 average (2.1%). Finland has been incapable of solving the serious problem of unemployment and the growing threat of exclusion and poverty in the domain of social development. In addition, the overall development of an information society in Finland is only at an average international level. Furthermore, in the light of EIS (European Information Service) indicators, Finland seems to be losing momentum in high-tech patenting, in the share of employment in high-tech manufacturing, and in non-technological innovation amongst SMEs. A challenge identified recently concerns marketing skills and the commercialisation of technological know-how and development. (Ibid. 2005.) The recently published technology barometer does not straightforwardly give support to the status of Finland among top economies globally (Naumanen 2005). Actors within the innovation policy field are increasingly paying more attention to these problems. A high position in global comparisons does not as such necessarily help much in designing policies ensuring respective positive development in the future. The continuation of an effective innovation policy is a general challenge for the Finnish economy in the future. In that respect, there are needs to ensure continuous knowledge flows between private and public actors. In the following, the developments and actions aimed at enhancing the linkages between universities and industry are addressed from the government's viewpoint. It is to be noted that industry itself has also been keen to enhance interaction between universities and firms. However, industry's contributions and actions to promote interaction between university and industry fall out of the scope of present study.

4.2 Universities and science and technology policy in Finland

Over the past decades there has been a determination to improve Finland's international competitiveness by investing in research and technology development, which today are seen as an integral part of innovative activities. Since the late 1980s especially, a key task of Finnish science and technology policy has been to ensure the balanced development of the research system and to promote co-operation within it.

The Science and Technology Policy Council of Finland, chaired by the Prime Minister, has had a visible role in the co-ordination of science and technology policy activities at a national level since the late 1980s. Other governmental organisations with key responsibility with respect to science and technology policy are the Ministry of Education and the Ministry of Trade and Industry. The Ministry of Education is in charge of matters relating to education and training, science policy, institutions of higher education, and the Academy of Finland. The Ministry of Trade and Industry deals with matters relating to industrial and technology policies, the National Technology Agency (Tekes) and the Technical Research Centre of Finland VTT. Nearly 80% of government research funding is channelled through these two ministries, in particular through Tekes and the Academy of Finland. The relative simplicity of the Finnish governmental structure and the small size of Finland's research system are seen as factors that facilitate policy-making and the co-ordination of activities (Science and Technology Policy Council of Finland 2003).

R&D investments

Over the years, a prominent feature of Finnish science and technology policy has been to set targets for R&D expenditure in relation toGDP. In international comparisons, Finland is third in the world after Sweden and Israel in terms of R&D percentage of GDP, with total R&D expenditure amounting to about 3.37 per cent of GDP in 2004 (Statistics Finland's estimate). Most of it – close to 70 per cent – is carried out by businesses. The increase in overall R&D expenditures partly conceals the fact that one company, Nokia, is responsible for a significant share of industry R&D expenditure. An estimate made by Ali-Yrkkö and Hermans (2002), holds that excluding Nokia's share of total R&D expenditure would decrease Finland's R&D intensity by one point, leading to 2.4 per cent at that time. Simultaneously with the increase in corporate R&D funding, public R&D expenditures increased significantly from 1996 onward because of the government's additional funding programme for the years 1997–99. Additional funding was channelled primarily through the Academy of Finland and Tekes (see also Nieminen 2005).

As part of the transformation of research and development, university funding experienced major structural changes in the 1990s. Firstly, specific budget regulation was replaced by operating cost budgeting. The government funding

for R&D awarded to universities was not earmarked for predefined targets but universities could decide its use themselves. Secondly, since 1994 the universities and the Ministry of Education have made an annual agreement on targets (for example, the number of master and doctoral degrees). As a consequence, the effectiveness of universities in meeting these targets influences the amount of available resources in the following years. A third change is related to extramural research financing. Public R&D financing is allocated more and more on a competitive basis, aiming at promoting technological development and its utilisation (Hakala et al. 2003, pp. 39–47). Due to the structural changes and competition, Finnish universities have become more responsive to external changes. Consequently, this has created strong incentives to seek new financing sources (i.e. EU and industrial funding) and to facilitate the transfer of knowledge and pursue commercialisation of their scientific research output.

During the period 1991–2003, direct government funding for R&D has tripled. The growth of extramural funding has been even more considerable. While the relative share of extramural funding of total university R&D expenditure was 36 per cent in 1991, it accounted for over 57 per cent of universities' R&D expenditures in 2003. Respectively the funding base for university research has become more diverse. The most significant single funding source for university research has been the Academy of Finland. During the considered period, its relative contribution has decreased from 42 per cent in 1991 to 32 per cent in 2002. Overall, university expenditure on R&D has experienced a moderate growth in applied research. The growth in financing for applied research is related to the growth in finance from Tekes, the domestic business sector, the EU and ministries' funding. Funding for basic research has also grown, but slower than funding for applied-oriented research. Tekes' share accounted for 16 per cent of all extramural funding in 2003, which is almost the same as in the mid-1990s. The relative share of business enterprise funding has also remained at almost the same level as it was in the early 1990s. (Statistics Finland 2001, 2003.) The growth in public research funding has somewhat compensated for the development of direct financing from enterprises. In fact, co-operation between universities and firms is more and more likely to occur within the framework of publicly-funded projects (e.g. Tekes, ministries and the EU) (Kaukonen 2004, p. 73). Thus, the developments in the financing structure of university research suggest that the government's role in supporting applied research and also

university-industry collaboration is strong. This leads to the question of the real market demand for university-industry collaboration.

The policy guidelines emphasising the increasing funding competition and the success story of Finnish information and communication technologies have altered the disciplinary structure of universities in a short time (Häyrinen-Alestalo et al. 2000). According to Nieminen's (2005) investigations, universities with large natural scientific, engineering and medical faculties were able to attract more external funding than other universities. By discipline group, the highest share of external funding can be found in engineering, agriculture and forestry and the natural sciences (55–60% in 2000). Funding sources vary among discipline groups. The highest share of National Technology Agency and company funding, which both fund industrially relevant research, can be found in engineering (39% of all research expenditures in 2000), natural sciences (23%), and medicine and health care (21%), while in other disciplines it is significantly lower. The highest share of funding from the Academy of Finland can be found in natural sciences and humanities (20% of research expenditure in 2000), a smaller extent in social sciences, medicine and agriculture, and the least in engineering (10%).

Project funding has changed not only the organisational structure, operating styles and methods, but also the power structures of the Finnish research and development system. Power has been more or less transferred from academic researchers to professionals of the science and technology policy administration (Lemola 2004). In parallel with these structural changes the entire scientific world has experienced growth in the financing of interdisciplinary research (Hakala et al. 2003, pp. 53–54). As a result of increased external funding and their duties as service providers, various interdisciplinary and independently organised research units, centres and institutes have been established within universities (Hakala et al. 2003; Oksanen et al. 2003; Kaukonen 2004, pp. 77–80).

The dominance of the economic approach

During the 1990s, apart from investing in science and technology, various policy instruments have gradually been set in order to create the conditions for favourable structural development. (Lemola 2004, p. 269; Nieminen 2005,

pp. 87–88). Table 2 summarises the major policy instruments in promoting academic, economic and societal targets in Finland in the 1990s and early 2000s.

Table 2. Selected policy schemes to promote academic, economic and societal targets in Finnish S&T policy in the 1990s and early 2000s.

Academic targets	**Economic targets**	**Societal targets**
• Increased support for the Academy of Finland • In Academy funding, scientific quality is pursued vigorously to the virtual exclusion of any alternatives • Establishing doctoral schools • Establishing Centres of Excellence Directing question: **How do universities contribute to the advancement of knowledge?**	• Increased support for Tekes funding • Numerous efforts and schemes to promote technology transfer and the creation of new start-ups • Gearing networking, research and education to the promotion of industrial innovation and competitiveness • Growing importance of IPR at universities and public research organisations • Engagement of university researchers in commercial utilisation of research results • Establishing university business liaison offices, technology and science parks, and technology transfer companies Directing question: **How do universities contribute to competitiveness and economic growth?**	• Increased need for societal relevance in research • Focus on societal impact of research and development instead of effectiveness • Recognition of the importance of social innovations • Regional development Directing question: **How do universities contribute to societal and regional welfare as well as sustainable development?**

Since the 1980s, the economic rationale of science and technology has played a dominant role. This is shown by the increased co-operation between university

and industry and a significant increase in Tekes funding. The development towards closer linkages between science and the economy is also accelerated by new policy schemes and seed finance intended to encourage the development of promising university IP and spinout activity. In addition, more funds are awarded on a competitive basis and through intermediate public funding bodies. Universities are expected to put more emphasis on business partnerships. Counter-balancing this development, academic research in universities has been taken care of with increasing funding from the Academy of Finland. The funding decisions of the Academy have been made largely on the basis of research quality and scientific qualifications. Graduate schools and centres of excellence have made important efforts to upgrade the academic tradition in Finnish science and technology. The Government has increased its support to both Tekes and the Academy, but it has not provided a parallel increase in the flow of funds to the universities themselves. The growth of competitive-based funding can be seen as an attempt to increase the societal accountability of university research. Furthermore, there has been an intention to improve the international quality of academic research.

The co-operation between universities, public research institutions and firms is considered a specific strength of the Finnish system of innovation. Despite policy efforts to promote the utilisation and dissemination of knowledge and technology, Finland performs relatively poorly in the commercialisation of research ideas and technologies emerging from universities and public research organisations. According to some estimates (Paasivirta & Valtonen 2004) about 250–300 science-based business ideas emerge in Finland annually, but only a few of them lead to the establishment of new start-up firms. Improving academics' entrepreneurial awareness and skills has been recognised as one of the major challenges in Finland (Arenius et al. 2001; Ministry of Trade and Industry 2003).

In 1980s and 1990s Finnish science and technology policy has paid relatively little attention to promoting societal objectives, such as enhancing the democratic participation, health, security and equality of citizens (Häyrinen-Alestalo 2001; Pelkonen 2003). In addition, the co-operation between public and private actors has been emphasised mainly from the perspective of scientific and economic competitiveness. Even though the societal dimension of research has not been at the centre of the objective setting of science and technology policy

(Lemola 1999), it has occasionally been echoed in national policy. Societal objectives briefly came close to technology policy in the 1980s, when the Council of State decided that technology policy should also promote the achievement of societal goals and that the introduction of new technologies should promote gender equality, employment, living standards, the quality of the environment, and the availability of services (see Lemola 2001). Environmental improvement was an area that gained particular attention in technology policy during the 1990s (Lemola 1999). In an article about the relationship between societal policy objectives and technology policy, Pelkonen (2003) states that technology policy has become a kind of "super policy", the targets of which have filtered down to other policy areas (p. 59).

Several initiatives point to intensified policy interest in the societal aspects of research and development. For instance, the 2003 Review of the Science and Technology Policy Council of Finland states that "Apart from technological innovation, this requires systematic input into producing social innovations geared to prevent societal and social development from diverging from economic and technological development" (2003, p. 2). It is important to notice that, while the previous policy conception of innovation was related to technological development, the current policy view now anticipates the importance of social innovation in facilitating economic and societal development.

Social innovations are also in the focus of The Finnish National Fund for Research and Development (Sitra 2004), which is devoting more funding to research that is geared to international challenges and global changes affecting Finland. Given the Academy's emphasis on basic science and the apparent weak connection between basic research results and innovation, the Academy is facing the challenge of excellence and the promotion of knowledge that is relevant to society (Gibbons et al. 2004). The evaluation panel argued that scientific excellence devalued with respect to social relevance, but advocated the continuation of the present policy, coupled with the development of new mechanisms for intensifying the collaboration with other funding bodies within the Finnish research system (Ibid. 2004, p. 40). Despite the above claim about the Academy's weak role in promoting interdisciplinary research, some research programmes of the Academy have been selected and launched in order to stimulate research in areas of societal relevance. These programmes thus

facilitate interdisciplinary activity inside Finnish universities and the opening up of university research to society.

The evaluation of Finnish experiences in the Fifth EU Framework Programme points to the conclusion that awareness and acceptance of societal goals as both evaluation criteria and project targets have been increasing among academics, as compared to the experiences in previous programmes (Uotila et al. 2004). Yet another tangible indication of the increasing importance of the societal dimension of R&D is the growing demand for the societal impact of public-funded research to be demonstrated. For instance, the Technical Research Centre of Finland (VTT) has carried out several studies that have examined the socio-economic impacts of its research and development (see e.g. Kutinlahti & Hyytinen 2002; Oksanen 2003; Kuitunen & Hyytinen 2004). Besides legitimising the use of public funding by demonstrating the societal and economic impacts of research projects on stakeholders, this information is aimed at assisting the organisation in directing its research strategies to better serve the demands of customers and society.

These examples give only a limited picture of the ongoing developments in the field of science and technology policy. It may be too early to say that new governance of research and development is taking place. However, the above-mentioned observations imply a more multiform and complex role of science and universities in society than simply academic and economic roles. Further knowledge of the societal demands as well as the societal impacts of research would greatly contribute to understanding the multidimensional roles of universities within the information society.

4.3 Policy guidelines for commercialising academic research

In Finland, the policies concerning university-industry relationships and the commercial utilisation of research results have changed over the years. This is shown in the policy reviews of the Science and Technology Policy Council of

Finland[6], whose opinions and recommendations drive the above-mentioned policy-making. Furthermore, the Council's conception of the relationship between science and industry is of great importance in understanding the operational activities carried out at universities. Table 4 summarises the main characteristics and status of the university-industry relationship as defined in the reviews of the Science and Technology Policy Council of Finland.

Table 3. The policy conceptions of the university-industry relationship and commercialisation in the reviews of the Science and Technology Policy Council of Finland, 1979–2003. (Science Policy Council of Finland 1979; Science and Technology Policy Council of Finland 1987, 1990, 1993, 1996, 2000, 2003.)

Role of university in the R&D system	**Interaction between universities and industry**	**Utilisation of research results**	**Measures and initiatives**
Producer of knowledge and supplier of skilled labour force and expertise (Reviews of 1979–1990)	Underlines the importance of trained labour force and expertise as prerequisite for utilisation of research	The publicity is a prerequisite for utilisation of research results; Dissemination of research results through publications and collaboration	Scientific information services Technology programmes
Supplier and disseminator of scientific and technological knowledge (Reviews of 1993–2000)	Underlines the co-operation between all producers and users of new knowledge in order to promote competitiveness of economy; Attention is also paid to regional and international developments	The dissemination of new scientific and technological knowledge Universities are expected to support the competitiveness of industry	Technology and cluster programmes Technology centres and science parks ; Developing expert services; Financing schemes for start-ups; Public equity investments
Supplier of new knowledge and facilitator of technological and social innovations (Reviews of 2000–2003)	Underlines the role of universities in supporting the emergence of innovations in collaboration with firms.	Emphasises academic entreprneurship and equal partnership with industry; apart from economic innovations, social innovations become more and more important	Reform of legislation for University invention Horizontal co-operation

[6] Riikka Eela (2001) has analysed the Reviews of the Science and Technology Policy Council of Finland, paying particular attention to the value basis of policy making in the field of science and technology.

On the basis of the Reviews launched by the Science and Technology Policy Council of Finland, three main phases can be seen in the way the utilitarian role of universities is envisaged from the 1970s onwards. The first phase emphasises the role of universities as suppliers of skilled workforce and expertise. The second phase, starting from the late 1980s, considers universities as suppliers and disseminators of new knowledge and technology. In this period policy emphasis is in particular placed on universities contribution to economic growth. The most recent phase emphasises the supply of new knowledge and the facilitating of technological and social innovations.

Supplier of highly skilled labour force and knowledge

University-industry links are a long-standing feature of the Finnish research system. However, it is only since the 1970s that the instrumental and utilitarian view of the transfer of knowledge from universities to society and economic growth has become a part of the national research policy. Many policy doctrines in the 1970s were adopted from Sweden and the OECD (Luukkonen-Gronow 1975; Lemola 2004). As soon as one-sided evolutionary theories concerning the "scientific-technological revolution" and "science as a direct productive force" prevailed, government policies were carried out on the basis of the national consensus approach (Alestalo 1979, 1991). Instead of asking "is scientific knowledge true?", it was increasingly asked "how effective is science?" (Ibid. 1991, p. 31). In the 1970s, attention was also paid to 'social relevance' and the advancement of welfare state objectives through democratic social policy (Alestalo 1993, 1997; Kaukonen & Nieminen 1999; Nieminen & Kaukonen 2001).

In the early 1980s, several policy reforms paved the way to the utilitarian concept of university-industry relations and towards establishing closer links between science and technology. The first was the establishment of the National Technology Agency (Tekes) in 1983. It started funding technology programmes which included collaboration between universities, state research institutes and firms, as well as development projects proposed by firms (Lemola 2001; Miettinen 2002, p. 81). The technology programmes aimed at gaining new technology expertise and product development options in business areas deemed important for the future, as well as supporting international expansion.

During the 1980s, Tekes' technology programmes were focused on assessing and managing rapidly developing technologies (e.g. ICT and material technologies and biotechnology) for industrial purposes. More recently, internationalisation, foresight, environmental and societal well-being have also been emphasised in the programmes (Halme et al. 2004). Based on a number of evaluation studies (see e.g. Arnold et al. 2002), technology programmes have ensured a solid base for industry and for co-operation with research institutes, thus generating expertise and knowledge.

From the viewpoint of university-industry linkages, an important policy reform was the greater emphasis on fund strategic/target-oriented research, which laid the foundation for intersectoral and interdisciplinary research. Although the debate on Mode 2 type of research only gained stronger policy status in Finland in the late 1990s, elements of networking and interdisciplinarity were already recognised in the 1980s. For instance, the Technology Committee set by the Ministry of Trade and Industry – which was asked to make recommendations for promoting the competitiveness of Finnish industry – states in its report that:

"one feature typical of technology projects is that they encompass R&D which goes beyond the material and mental resources of individual organisations. Technology projects can also promote collaboration between various organisations and branches of research, thus improving the efficiency of R&D by gathering small and still fragmented resources into wider, and more effective, entities. At the same time, industry's interests in more long-term targeted research can be increased" (Technology Committee 1984, pp. 8–9).

The promotion of international co-operation in the field of science and technology has been central to Finnish science and technology policy since the 1980s. Finland joined European activities such as Eureka (1985), the European Organization for Nuclear Research CERN (1991), and the European Space Agency ESA (associate member in 1987 and full membership in 1995). An important step in the internationalisation of Finnish science and technology was taken in 1995 when Finland joined the EU. From that moment onwards, the European Framework Programmes have been among the most influential policy measures in this respect (Luukkonen & Hälikkä 2000; Niskanen 2001; Uotila et al. 2004).

The internationalisation of R&D is today considered a top priority for Finnish S&T policy. In a small country like Finland, such policy is justified by the fact

that in many specialised research fields relevant colleagues can only be found abroad. Another argument in support of internationalisation is the need to ensure international top quality research (Hakala et al. 2002). Internationalisation is viewed as a competitive advantage for science and technology and enables economic competitiveness (Hakala et al. 2003, p. 148). A third argument, that has become increasingly important in the current globalising environment, is to ensure the dissemination of knowledge between public and private sectors and the commercialisation of academic research. This final development emphasises internationalisation as an absolute requirement for managing global competition (Science and Technology Policy Council of Finland 2003, 2004; Halme et al. 2004).

Despite the central position of internationalisation as a policy target, there are few studies that have examined the impact of internationalisation on Finnish university research (see e.g. Hakala et al. 2002). The present study offers further insights into the impacts of the EU framework programmes on Finnish science and technology, by focusing on university-industry interaction and the commercialisation of academic research, as well as on their relative significance to university research.

From supply to dissemination of scientific and technological knowledge

The second wave of government policies toward establishing tighter links between universities and industry took place in the early 1990s, when the "national system of innovation" concept (NIS) was introduced by the Science and Technology Policy Council of Finland (1990). The Review of 1990 defined a national innovation system as "the totality of factors that influence the development and utilisation of new knowledge and expertise" (p. 21). The significance of interaction and networking was stressed in subsequent reviews. For instance, the 1996 Review defines the national innovation system as a domain of interaction between producers and utilisers of new knowledge. This definition underlines the significance of establishing different kinds of networks as a way to advance the utilisation of knowledge. As a result, the NIS-based policy offered an opportunity to take a broad and systematic approach to policy making and to emphasise research and education, thus improving the competitiveness of Finnish business (Miettinen 2002).

Within the NIS-policy, universities and research organisations were increasingly seen as an essential part of economic development and of competitiveness-based knowledge and innovation. One might say that the implementation of the NIS concept has fostered an entrepreneurial spirit in universities. The adoption of the economic rationale by universities was accelerated by the economic recession into which Finland plunged during the early 1990s. Since then, more research funds have been awarded on a competitive basis and through intermediate public funding bodies (Nieminen & Kaukonen 2001; Nieminen 2005). Universities were also pushed towards redefining their mission, goals and strategies in order to become competitive on the basis of their input-output ratio and marketable activities (Häyrinen-Alestalo et al. 2000, p. 166).

The NIS-inspired innovation policy played an important role in the adoption and implementation of some major science and technology policy measures. Throughout, a series of policy and institutional efforts were made, all intended to strengthen the capabilities of public sector research to generate and transfer knowledge, to harness the commercial potential of their work and to facilitate the emergence of academic spin-offs. There have been three major initiatives promoting cross and intra-sectoral collaboration at a national and/or regional level, in particular. The single most important ongoing activity has been *Tekes' technology programmes*. These technology programmes aim at obtaining new technology expertise and product development options in the business areas important for the future and for supporting international expansion. The programmes have also offered a feasible framework for international R&D co-operation, e.g. participation in the EU framework programmes. The second initiative, *the Cluster Programme,* initially funded through the programme for additional R&D funding launched in 1997, aims to support R&D activities that strengthen clusters and collaboration between industry and public organisations and company-to-company co-operation in specific fields of industry, or around certain themes. These programmes are jointly financed by Tekes, the Academy of Finland and the respective ministries. The third initiative, *the Centre of Expertise Programme*, is a national measure aiming at enhancing regional competitiveness by strengthening innovation, renewing the production structure and creating new jobs within the expertise areas selected. The Centre of Expertise programme acts as a regional contact point for companies and public research organisations.

Many of the completed national technology and cluster programmes have been the subject of extensive international and national evaluation exercises. These evaluations have provided insights into the implementation of the programmes as well as their relevance to society as a whole. On the basis of the general evaluation of the technology programmes carried out in 1999, technology programmes have ensured a solid base for industry and for the co-operation with research institutes and the generation of expertise and knowledge. The programmes have been criticised for being too technology-oriented, fragmented and conventional (Tuomaala et al. 2001). Moreover, the assessment concluded that the cluster programmes have succeeded in initiating a degree of productive co-operation and increasing the market-approach of research. The improvement of co-ordination among finance providers was regarded as the challenge (Prihti et al. 2000).

Aside from launching financial programmes for the utilisation of knowledge and know-how, the intermediate level of innovation support was strengthened. The framework in support of the commercialisation of inventions emerging from public research organisations currently comprises a large number of actors and platforms, such as technology centres and science parks, seed funding organisations, technology transfer companies, incubators, enterprise training, incubation facilities and industrial liaison offices. They all are aimed at bridging the gap between the different actors in the research system, creating synergies between them, marketing the research strengths of universities and advising universities and other public research organisations on commercialisation.

The extent to which these "bridging organisations" have enhanced the commercial utilisation of knowledge and the creation of linkages between science and industry has not been systematically studied in Finland. Nevertheless, a large number of actors involved in the intermediary level points of dense networks are possibly constituting a barrier to the goal of setting up a "one stop" agency in each region. The evidence gathered for the evaluation report of the Finnish innovation support system suggests that overlap within support system institutions exists (Ministry of Trade and Industry 2003, p. 113). This in turn calls for a clearer identification of the systemic failures, if direct government policies in these areas have to be justified.

Suppliers of new knowledge and facilitators of technological and social innovations

At the end of the 1990s, policy attention was increasingly paid to the economic and commercial contributions of university research. As opposed to the 1980s and early 1990s, university researchers were encouraged to apply for patents of their own, to commercialise their inventions and start spin-off companies. This policy shift is reflected in the 2000 and 2003 Reviews of the Science and Technology Policy Council of Finland that laid out, even more clearly than previously, that universities should take a more active role in disseminating their results to business. What makes this different from earlier views is that universities were regarded more or less as equal partners with industry in commercialising research ideas emerging from public science. Nevertheless, the Council acknowledges the potential problems that may arise in sharing the economic benefits of co-operation and therefore calls for clearer rules concerning both ownership policy and utilisation rights. In the 2003 Review the Council acknowledges the need for the juridical reform of university ownership, by recommending that "Research organisations will be developed as active and dynamic partners with a view to strengthening linkages between research and business. At the same time, care will be taken to ensure the balanced development of their resources. Co-operation rules and procedures will be clarified and developed to provide more incentive" (p. 37).

The shift in government policy towards a stronger economic role for universities was manifested in the late 1990s by several governmental working groups that sought to alter the regulation of university inventions (Ministry of Education 1998; Ministry of Trade and Industry 2002). The existing norms regulating the business activities of university professors were seen as being far too few to be used as actual instructions in departments (Tuunainen 2004). The proposal for a new Act to deal with university inventions was prepared jointly by the Ministry of Education and the Ministry of Trade and Industry. The proposal included guidelines to enhance the commercialisation of university inventions, secure the position of inventors and improve the contractual practices related to research. The new Act would revise the so-called "teacher clause" that gives university inventors the rights to their inventions. Specific circumstances allow the university as employer to take possession of the rights related to the employee's inventions. In collaborative research, the university could obtain the rights of the

inventions created by its employees. In such cases, the university would be responsible for the costs involved in the protection. However, in contract research, the principal rule is that the rights of the invention are owned by clients, who, in turn, are responsible for the protection costs. (Hallituksen esitys eduskunnalle... 2004.)

The new Act has certain implications for university practices and the work of university researchers. From a university and department perspective, it obliges universities to improve the dissemination of research results produced within their organisations. This, in turn, calls for more efforts to develop the management system, to clarify internal rules, to develop strategies for commercialisation and to find more financial resources to cover the costs of protecting intellectual property. In terms of the work of individual researchers, such changes in the legal framework imply that their right to decide upon the utilisation of their inventions would be restricted. Researchers are also required to announce their inventions, regardless of the type of research funding from which the invention emerged. It is stated, however, that the researcher has the right to obtain some compensation for transferring the rights to the institution. The compensation would not be full-cost compensation, however, but more or less an incentive, and would be determined according to the conditions under which the invention was created.

The new legislation concerning universities' third function makes universities legally responsible for disseminating the research results produced within their organisations. This fact poses new challenges for the development of university practices and the management of the commercialisation of research results. Even though several European countries, such as Germany and Denmark, have abolished the individual privilege to exploitation and IPRs, it is still unclear which regulative framework would be preferable to enhance the commercialisation of universities' inventions (Polt et al. 2001).

The conception that universities' third mission includes only commercial activity has been criticised because of its narrowness. For instance, Kankaala et al. (2004) see universities' "Third mission" as being rather a perspective on the universities' societal role than a clearly defined function:

"The third function of universities is more a question of the societal influence perspective than a clearly defined function. It is not worth strictly defining its nature or intention from a single viewpoint. The 'third function' does not just simply refer to the fact that universities should serve firms and society, but rather that universities should serve the development of civic society." (Ibid. 2004, p. 133.)

In the 2003 Review, the societal relevance of research is also extended to the functions of universities. The Science and Technology Policy Council of Finland notes that:

"The transformation in the economy and society will extend the tasks of the traditional players in the innovation system ... players in the education and research systems and in the public administration are faced with larger development responsibilities. This also concerns overall information society development..." (P. 37.)

The 2003 Review puts forward the view that:

"Higher education institutions and local units of research institutes have a special task in adding to the knowledge and social capital of the region and making it available to users." (2003, p. 41.)

The Council's view may add new elements to the debate on the "third function" of universities as it emphasises the economic role of universities in the commercialisation of research results. The justification of the policies concerning the role of universities is based on expected economic benefits in terms of new innovations and firms, productivity gains, employment and economic growth (see also Häyrinen-Alestalo et al. 2000).

Prior research has found that even though the number of patents issued to universities and public research institutions has increased rapidly in the US, EU and Japan since the mid 1980s, licensing has not been a very successful way of transferring IP to industry (Packer & Webster 1996; Owen-Smith 2001, 2003; Bok 2003; Lambert 2002). Also, the experience of US universities demonstrates that technology transfer through licensing is not usually a large revenue generator for universities (Bok 2003; OECD 2002b). Success in commercialising the university's inventions varies according to the institutions. Henderson et al. (1998) note that the observed increase in university patenting may reflect an increase in their "propensity to patent" – and possibly an associated increase in the rate of knowledge transfer to the private sector – rather

than an increase in the output of important inventions. Patents are generally valuable to universities because they increase their institutional reputation, by advertising their success, broadening the audience for research and possibly attracting potential research collaborations.

In summarising the above discussion, the underlying rationale as to why universities would have an interest in putting more effort into the development of commercial activities is that such activities would provide an additional source of income when budgetary pressures are strong. However, experience from elsewhere in the world indicates that university inventions have rarely generated significant income for universities. Therefore, the financial incentives may not alone be sufficient reason for universities to engage in commercialising research and legitimising their actions.

4.4 Implementation of policies for commercialisation

4.4.1 The main policy actors and schemes to promote commercial utilisation of research

The primary public actors supporting both the interaction of university and industry, as well as the commercialisation of research results are the National Technology Agency, (Tekes), the Finnish National Fund for Research and Development (Sitra), the Foundation for Finnish Inventions and the Employment and the Economic Development Centre (TE-centre). In addition, Finnish Industrial Investment Ltd, Finpro, Finnvera, a network of science and technology and science parks and a networks of centres of expertise, university liaison offices, and university/research institute-based private technology transfer companies (e.g. Licentia ltd) represent the intermediary level of the supporting structure. The Technical Research Centre of Finland VTT also needs to be mentioned because it is one of the largest single actors in technology transfer in Finland. In other public research institutes, efforts devoted to technology transfer vary widely.

In Finland, the structural framework for promoting innovation and the commercialisation of research is dense, as it emerges from the number of actors involved in supporting R&D. The co-ordination between state agencies and a

more transparent innovation support system is seen as one of the challenges in developing the Finnish innovation system (Ministry of Trade and Industry 2003). The goal of setting up a "one stop" agency in each region may, however, be difficult to achieve given the potential rivalry between national agencies.

The 1990s and the early 2000s have seen a series of policy and institutional efforts intended to strengthen the abilities of public sector research to generate and transfer knowledge, to harness the commercial potential of research results and to facilitate the emergence of academic spin-offs.

Briefly, three main lines of policy aiming at encouraging the commercialisation of academic research can be distinguished:

1. promoting and developing co-operation between industry and public research organisations

2. developing better conditions for knowledge and technology transfer and strengthening the abilities of industry to absorb new knowledge

3. improving the use of intellectual property rights (IPR) by universities and public research institutes.

The above categorisation is not mutually exclusive. These interest areas have their own specific targets (e.g. to provide financial resources or to raise public awareness towards university-industry relations).

In addition to research collaboration, the main mechanisms through which knowledge generated by universities and other public research organisations is transferred to industry are licensing and university start-ups. Licensing is less resource-intensive than spinning out new companies. It is often the quickest and most successful way of transferring IP to industry, and has the advantage of using existing business expertise rather than building this up from scratch (Lambert Review 2003).

In the mid 1990s and early 2000s, a range of support schemes aiming at enhancing the commercialisation of research results generated by public research organisations was launched. Table 6 contains the main policy schemes promoting the commercialisation of technology and research-based start-ups.

Table 4. Selected policy schemes for promoting the commercialisation of research results and the creation of academic spin-offs.

Policy measures for supporting the commercialisation of academic research	**Need for support**
TEKES' supporting schemes: • Technology programmes • Start-up loans	Collaboration between universities and industry Business start-up Proof of concept funding to establish whether a new technology is commercially viable or not. Enhancing SMEs to utilise new technology-based methods and research services Promotion of the adaptation of specified technologies for problem solving in SMEs in order to introduce new technological opportunities and raise their awareness of external R&D resources.
Government's Entrepreneurship project (2000–2003)	Increase the establishment of new firms and the growth of existing companies
SITRA's support schemes: • Funding for companies to enable them to produce professional and reliable business plans in order to attract initial funding (joint effort with Tekes) • A forum through which companies are introduced to private investors. • A channel through which an entrepreneur can find experts with wide experience of international sales and marketing	Support for university-based start-ups and the commercialisation of research results • Business start-up • Management • Risk assessment • IPR management
TE-Centres Several funding schemes and training services for supporting new businesses (i.e. Assistance in early-stage problems and support, and training in business development)	• Promotion of entrepreneurship
The Foundation for Finnish Inventions instruments and services • Grants, loans and advice for developing inventions, paying the costs of patenting, product development and commercialisation by private inventors and small entrepreneurs	• Promotion of commercialising research-based inventions

University business liaison offices, public research institutes and intermediary organisations such as science and technology parks, TE-centres and technology transfer companies play a significant role in developing business networks, marketing the research strengths of universities, advising on consultancy agreements and contract research, and most notably arranging complex collaborative research agreements. Moreover, enterprise training institutions, incubation facilities and industrial liaison offices act as bridges between universities and enterprises.

Meyer's et al. (2003) study on university-related patents in Finland is one of the pioneering works attempting to quantify Finnish universities' involvement in commercialisation. Altogether they studied 530 Finnish patents that were filed in the 1990s. The study shows that almost half of all 530 surveyed patents were related to researchers working in only two of the twelve surveyed Finnish universities, suggesting a high polarisation of commercial activities. The five most inventive universities were the University of Helsinki, the Helsinki University of Technology, the Universities of Turku and Oulu, and the Tampere University of Technology.

Telecommunication and instrument-related patents represented the most numerous group of the thirty examined technological sectors. Innovative activity is not only concentrated in a few Finnish universities and technological sectors, but there is also a relatively small number of university inventors. The most active 10% of Finnish universities' inventors accounted for more than a third of university-related patents. The concentration of assignees was even stronger than the inventor concentration. Nokia, Orion, Valmet and Fortum were the four largest owners of university-related patents. The study also concludes that start-up companies of academic entrepreneurs are not necessarily the most prominent channel for commercialising scientific knowledge. Only a little more than 10% of purely academic inventions were utilised in start-up enterprises. Large firms were the predominant partners for universities, reflecting the general view that established collaborations between individual researchers and industry play a considerable role when it comes to the transfer of knowledge and technology.

Despite the policy efforts to encourage the creation and to nurture university spin-offs, no reliable data exist to assess the success of Finnish universities in

that respect. Part of the difficulty arises from the fact that there is no common definition of what constitutes a public sector spin-off firm.

4.4.2 Improving the use of intellectual property rights by universities

In Finland, the proposed amendment concerning the regulation of university inventions has created some confusion among university administrators, scientists and firms. For instance, there is a concern that granting intellectual property rights (IPR) to a university institution instead of to individual researchers may on the one hand reduce researchers' interests in commercialisation, and on the other hand reduce the interest of firms in collaborating with universities.

To provide further insights into the ownership of university inventions and the potential implications of the growing commercial role of universities, a national expert workshop was organised in autumn 2003. In the workshop, 11 Finnish experts, including policy-makers, policy scheme managers, university academics and business representatives, discussed the changing regime of university engagement in entrepreneurial activities. They sought answers to questions such as why should universities own the inventions and how they should own them? What are the development needs for promoting the commercialisation of university inventions? What kinds of implications might university involvement in commercialisation have on university reputation and partnership with industry?

In general, it was viewed that universities' involvement in commercial activities will increase because of the growing importance of knowledge in the economy. The economic role of universities was, however, regarded as controversial, possibly giving rise to new tensions within universities. On the one hand these tensions arise from the difficulty of integrating commercial activity with universities' basic tasks, and on the other hand from the need to preserve the freedom and openness of research. Another difficulty is how to ensure that all parties in society have access to publicly funded research. In practice this does not always happen. Previous evidence suggests that large companies often have more resources to purchase and absorb knowledge and know-how produced by

universities and public research organisations than small and medium-sized enterprises (SMEs) do (Acs & Audretsch 1990; Santoro & Chakrabarti 2002; see also Edqvist 1997).

The legal reform to grant IPR to universities received both criticism and support from the workshop participants. The amendment of the Act was seen as justified by the argument that, ultimately, universities and university scientists are public servants, who ought to ensure the "public good". For this reason, it is hard to find grounds for why marketable innovations created with public funding should be owned by the researchers themselves. Part of the benefit of public investments should be returned to the source of the funding, i.e. university. Another argument for granting IPRs to universities was that it would enhance the opportunities for universities to develop commercial activities at an institutional level. Some experts thought that this would also be beneficial to individual researchers because the institute can provide them with a better position for negotiating with firms. It was argued that establishing rules and clarifying principles for commercialisation could help in finding the balance between entrepreneurial activity and other academic functions, providing a more transparent normative basis for university engagement in commercial activity.

Whilst the new Act would clarify the rules and ownership rights of university inventions, it does not solve or eliminate the barriers to and bottlenecks of commercialisation. According to the experts in the workshop, the structural and cultural factors were regarded as far more influential for success in commercialising research than the legal reform. The workshop discussion revealed several thoughts regarding the barriers to commercialising academic research. These were the lack of specific skills in commercialisation, lack of IPR strategies and rules and lack of financing for handling inventions.

The government has set broad guidelines for the exploitation of university IP and left it up to universities to decide upon their own priorities and management structures. With a few exceptions, most Finnish universities lack rules that set limits on the time academics are allowed to spend on consultancy, even though they are free to determine them. Furthermore, there is a great variation in the level of expertise and sufficiency of services. In the workshop, most experts shared the view that some innovation and IPR services may best be co-ordinated at a national level to limit the costs (for instance IP services in specific fields

such as biotechnology). Conversely, it might be reasonable to carry out some of these activities at an institute level in order to ensure staff's commitment to them.

Clarity over IP rules for successful research collaborations between industry and research organisations was regarded as a high priority among the workshop experts. Clear policies and rules are needed to avoid internal and external conflicts of interest and to increase the transparency of entrepreneurial activities taking place in university facilities. University engagement in commercial activities may not only increase suspicion among academics but also in the wider public. Nevertheless, it is prudent to acknowledge that when policies are top-down, the desire of universities to implement them may vary, especially since universities face conflicting incentives (Goldfarb & Henrekson 2003, p. 655). Some Finnish experts in the workshop stressed that companies need to know who has the right to negotiate over the IP and who ultimately owns the invention. Then collaboration can start. Without patent protection and exclusive licensing, firms would have little incentive to invest in the further development of university-based inventions. Some fears were expressed by workshop experts that universities may begin to overvalue their IP when the awareness of IP increases. This in turn may decrease the willingness of firms to collaborate with universities. According to company representatives, some Finnish firms are increasingly favouring bilateral and contract projects with universities, instead of collaborative projects with third parties where the results are available for all participants.

A further area that can be seen as a barrier to improving the use of IPR by universities is the lack of financial resources for managing IP and the further development of university inventions. Restricted financial resources to cover patenting costs and the potential conflicts in patent contest may also weaken universities' capabilities to protect their intellectual property rights.

Goldfarb and Henrekson (2003) have argued that putting property rights in the hands of the inventor does not automatically create the best incentives for commercialisation. Evidence gathered from the Technical Research Centre of Finland by Kutinlahti and Elo (2003) showed that in general researchers were weakly aware of the importance of IP issues. Furthermore, researchers often lacked both the resources and the motive to develop and market their inventions

further. Their knowledge of market development was scanty. The same study came to the conclusion that the general policy protocol had had little direct effect on the commercial activity, while the local group norms, i.e. the atmosphere in the research unit and the attitude of the unit's leader, played a more essential role in predicting entrepreneurial activities. However, the common principles for the protection of property at an institute level had helped to establish a good image of VTT as a reliable research partner. The integration of commercial targets into the research process was considered an important means to improve the use of intellectual property by the research institute (Ibid. 2003).

On the basis of the policy analysis, the discussion in the workshop and literature, universities will increasingly be involved in commercial activities. This being the case, a challenging question for universities is how they pair commercial activity with universities' basic functions, research and education. Finland, as well as other European countries, has sought new commercialisation models from the American system. However, it is important to take into account that that the American university system differs from the European universities in many respects. For instance, Henrekson and Rosenberg (2001) identify the existence of a comprehensive internal system for commercialisation as one of the four key aspects behind the emergence of science based entrepreneurship in the US. In contrast to their European counterparts, American universities are highly decentralised, intensely competitive, and have a high degree of institutional autonomy (Goldfarb & Henrekson 2003; Bok 2003; Pavitt 2000, 2001; Rosenberg 2000; Rosenberg & Nelson 1994; Crow & Tucker 2001; Owen-Smith 2003; Riccaboni et al. 2003). Imitating the American model of commercialising research results does not necessarily fit with European universities.

Given the policy efforts taken to strengthen the regulative framework for university engagement in entrepreneurial activity, it is important to know how universities react to these changes and what are the Finnish firms' expectations and responses to the universities' role in commercialisation. The next chapter will provide empirical evidence on the experiences and views of Finnish universities and firms on the entrepreneurial role of university.

5. University responses on entrepreneurial role

Many scholars have argued that university-industry research collaborations are important mechanisms for generating technological spillovers. They positively contribute to technological development and help in realising the full social returns of R&D investments (Martin & Scott 2002; Mansfield & Lee 1996). Despite the wide literature on the forms of and incentives for university engagement in collaboration with industry or commercialisation, there is still a mixed understanding of its possible consequences for academic research. Little is known about the path-dependency mechanism, organizational and/or cultural factors that favour or constrain university engagement in entrepreneurial activities.

The debate on the emergence of the entrepreneurial university is the starting point for this chapter. Based on the literature survey, two questions are key to understanding the entrepreneurial role of universities. First question is whether the involvement with industry is detrimental for the content and quality of university research as well as for university autonomy. Another is the question dealt with by Stokes and others (Peters & Fusfeld 1982; Blumenthal et al. 1986, 1997), whether academics are able to do basic and entrepreneurial research simultaneously?

University incentives and responses to the entrepreneurial role is studied by drawing on the two survey data with Finnish participants in the EU framework programmes in the late 1990s and early 2000s and interviewing university personnel. The surveys included questions about the goals, benefits and problems of research collaboration and commercial engagement, as well as differences with respect to the impact of participation between the different types of participants. The survey data is complemented by information drawn from some semi-structured interviews with 78 Finnish university staff members, representing 36 university departments and research centres. It must be noted that the interviewees were not the same people as the survey respondents. The interviewees were chosen as representatives of different universities, disciplines, university organisations (departments and research centres) and type of involvement in the EU framework programmes. The interviews were semi-

structured and typically lasted from 1 to 2 hours. The topics addressed in the interviews ranged from the research strategy of the department, EU collaboration and other international research programmes, commercialisation of research results and collaboration with industry. Attention is also given to organisational responses to the growing market demand and entrepreneurial role as well as the structural developments that occurred in the Finnish university sector in the 1990s.

It is to be acknowledged that different disciplines and individual researchers at universities vary in the way they experience the transformation of universities and in the qualifications they have to commercialise their research (Nieminen 2005; Peters et al. 1988). The transformation is said to be most pronounced in the life sciences and the commercial fields of medicine, pharmaceuticals and biotechnology (Powell & Owen-Smith 1998). The present study, however, does not seek to compare different universities or disciplines in facing entrepreneurial demand but rather it aims to identify the general characteristics and impacts of the entrepreneurial performance of universities.

5.1 Some methodological notions

5.1.1 The EU framework programmes as a tool for knowledge dissemination and utilisation

The framework programme for research and development is the European Union's most important form of R&D co-operation. A general aim, as defined by the Single European Act, which was approved in 1986 and which provided a formal legal basis for Community action in supporting R&D, relates the support of research activities within the European Community to economic aims and also aims to assist European industry in becoming more competitive. The Maastricht Treaty, signed in 1992, brought a number of new elements to Community policy. Accordingly, R&D activities were not limited to strengthening the science and technology base of industry but were extended to support other Community policy and contribute to increased societal and economic cohesion, enhanced employment prospects and a healthier environment in Europe. The current declared objectives of EU Framework Programmes include the promotion of European know-how, the technological

level of industry, and quality of life of its citizens. (European Commission 2003.)

Besides the constant changes in the objectives of the framework programmes, there has been a move towards greater technology orientation, which is more market-oriented. Meanwhile, projects seen as "risky" and long-term basic research have been neglected. A general shift towards market-driven research in the EU programmes is confirmed by the Finnish study of the experiences in the Fifth Framework Programme. Although EU projects rarely deliver immediate economic benefits in the shape of new products, patents or other commercially measurable results, on average Finnish enterprises felt there were more commercially significant results than in the previous framework programmes (Uotila et al. 2004). The learning experiences of the participation may also have facilitated the attainment of immediate benefits such as new or improved products. It is also often argued that dissemination and exploitation of results could be improved in a number of cases. However, the extent to which commercial utilisation has taken place in practice has been little studied.

Since the early stage of participation, Finns have been most frequently involved in information and telecommunications, life sciences and industrial and material technology programmes both in terms of project number and the frequency of participation (Luukkonen et al. 1999; Uotila et al. 2004). In the Fifth Framework Programme, the Finnish organisations were involved in 1444 projects. Since the Fourth Framework Programme, Finland's involvement in the EU's research co-operation has been more extensive than might be assumed on the basis of the country's own R&D investment (Statistics Finland 2001). This development can partly be explained by the Finnish policy emphasis on the internationalisation of R&D in general.

Research centres and universities have been the most active Finnish participants in EU framework programmes ever since their early participation. The share of large companies has varied from 12 to 24 per cent, standing at 12 per cent in FP5 (Uotila et al. 2004). In financial terms, the R&D funding received from the EU has increased steadily since 1998 (Figure 3). In 2004, Finland received 107 million euros from the EU, which comprised 2.0% of Finland's total R&D

expenditure. Over half of all EU funding was spent in universities (54%). The corresponding figures for the public research centres were 30% and firms 16%. The relative share of EU funding of total university R&D expenditure grew from 1% to 5.6% during the period of 1995–2004. Correspondingly, the share of EU funding of total Finnish enterprise R&D was 0.5% and public sector organisations R&D 6% in 2004. (Statistics Finland 1995, 2005.)

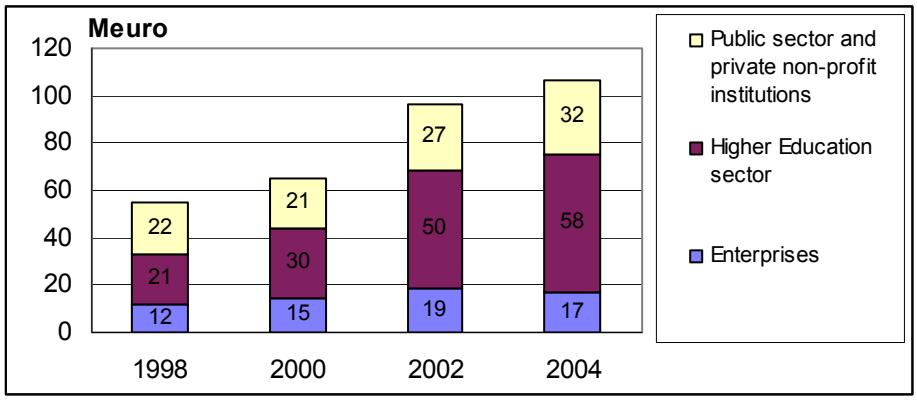

Figure 3. EU funding in 1998–2004 by performer of research and development (EUR million). Source: Statistic Finland.

Overall, EU funding has achieved a greater foothold in the universities' research funding. EU funding has increased more rapidly than total university R&D expenditure and also faster than total extramural R&D funding for universities. In 2003, EU funding accounted for 10 per cent of extramural university R&D funding and 5.6 per cent of total university research funding. By disciplines, in 2003 the largest share of EU funding in universities was spent in the fields of technology (28%) and natural sciences (22.5%). Since 1999 medical sciences, social sciences and technology have gradually increased their relative share of EU funding, while natural sciences and agriculture and forestry show a declining trend (Figure 4). Compared to figures for 1995, EU funding as a proportion of university R&D expenditure has increased most rapidly in agriculture and forestry (12.9% in 2003) and technology (8.2%) (Figure 5).

There has also been a tendency for the largest technical universities to be the most successful in gaining access to external funding. The University of Helsinki has been the single most active participant organisation amongst the

universities. In 2003, it accounted for 15 percent of total EU funding allocated to the universities. The next most active universities were University of Kuopio (12%), University of Oulu (8.8%). and Helsinki University of Technology (7.6%) (Statistics Finland 2005).

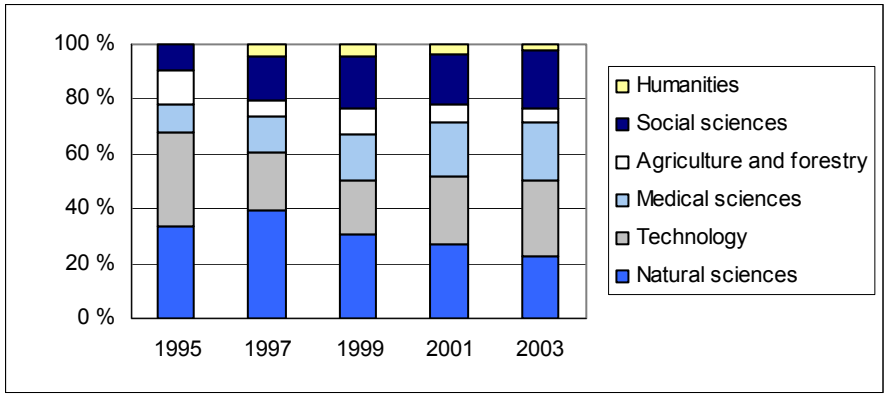

Figure 4. The discipline's share of EU funding directed to universities (%). Source: Statistic Finland.

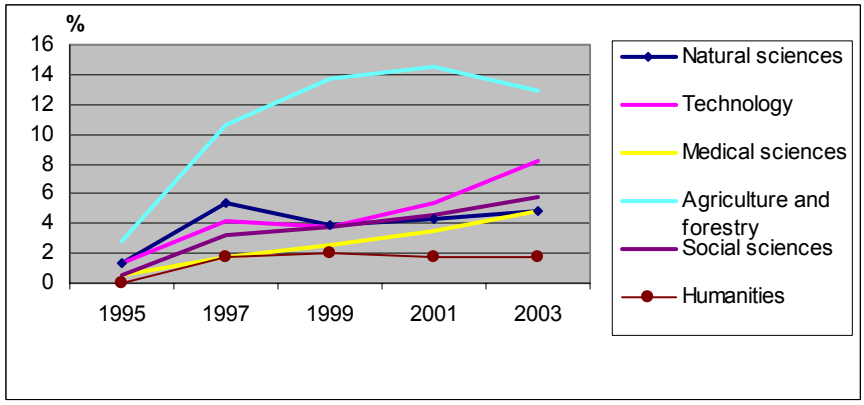

Figure 5. The relative share of EU funding of the discipline's total R&D expenditures in universities 1995–2003 (%). Source: Statistic Finland.

Even though the EU framework programmes have generally worked well and provided a valuable screening and training tool for industry, it is still highly uncertain whether collaborative projects have been successful in solving real-life

industrial problems and promoting dissemination and utilisation of research results (Peterson & Sharp 1998). In addition to the challenges related to the formation and maintenance of partnerships and the achievement of strategic synergy for all partners, the EU programmes nowadays face a number of policy issues. For example, how close to the market would the programme draw the line in defining technologies as "precompetitive", and therefore suitable for government funding? Moreover, in order to attract the best researchers Europe-wide, there is a need to find a balance between the promotion of scientifically world-class research on the one hand, and increasing the market orientation to satisfy the needs of industry on the other (see also Niskanen 2001; Luukkonen 2002; Uotila et al. 2004). The high workload involved in project preparation, project administration and the low probability of being accepted also pose challenges for EU cooperation.

On this basis it becomes crucial to understand why some university researchers and firms are keen to find new collaborative partners from the EU collaboration. More importantly, what potential impacts might the interaction between universities and industry have on university research work and the innovative activities of firms?

The impacts of research collaboration in EU framework programmes have been widely studied (see e.g. de Montgolfier & Husson 1995; Luukkonen & Niskanen 1998; Ohler et al. 1998; Niskanen 2001; Luukkonen & Hälikkä 2000), In comparison to previous analyses the approach adopted in the present study is novel in two respects. First, the analysis focuses on the implications of carrying out research projects with and without firms. This allows us to highlight the effects of research collaboration with firms on university behaviour and practices. Seconly, by utilising several surveys from EU collaboration and interview data with heads of university institutes collected in various phases of EU collaboration, it is possible to obtain better understanding of the relationship between EU participation, organisational and cultural changes and entrepreneurial activity. In general, this allows to consider the importance of the EU framework programmes in creating an entrepreneurial culture within Finnish universities.

There are some data limitations that need to be taken into account in judging and generalising the results of the analysis. As for the university responses to

commercialisation, the experiences from the collaboration with firms within the EU projects do not offer a complete picture of the consequences and problems related to the commercialisation of research. Compared to a random sample of university-industry projects, the projects analysed in this study are more likely to be perceived as having a high social value, technologically generic, and at an early stage of development and commercial utilisation. Being aware that the EU framework programmes do not directly aim at supporting commercialisation of academic research, it is, however, worth looking at these types of co-operations and outcomes in terms of the university-industry linkages.

There are also some limitations when it comes to making generalisations concerning the experiences of the Finnish university participants in the EU framework programmes. Firstly, university scientists participating in the EU projects are in a very different situation today than they were in the late 1990s. The participants' understanding of each other's goals has increased, and their learning processes of collaboration have changed the attitude towards partnerships and programmes in general. The more frequent and close the collaboration, the easier it is to find a common language and, consequently, to attain concrete results. Secondly, the objectives and priorities of the EU framework programmes have changed since the Fourth Framework Programme (executed in 1994–98). While in the Fourth Framework Programme the majority of the participants considered the projects to be focused on more applied and industrially relevant research (see Niskanen 2001; Hakala et al. 2002), the Fifth Framework Programme has allowed to pursue more academic goals than the previous programmes (Uotila et al. 2004). Thirdly, a possible problem is caused by the surveys and interviews being conducted at different times. It can be assumed that since the time of the data collection up to the present day, most Finnish universities have been in the process of reformulating their strategies in the area of commercialisation. In addition, the government has also been in the process of reforming the legal framework for the commercialisation of university invention.

5.1.2 Typologies for analysing university research approaches

The data in this chapter is analysed at both the individual and organisational levels. In order to give a more in-depth picture of university perceptions of their entrepreneurial role, the survey data is supported by quotations from the

interview transcripts. In this way the convergences and divergences of academics' views will be better highlighted. The interview data is analysed according to the typology developed in Section 3, which aims at characterising the diversity of university approaches to market demand. The four academic types are considered as follows. The Mertonian type of academic is oriented towards basic research and cares about autonomy. The pragmatically-oriented academic carries out applied research and does not regard interaction with industry as detrimental. The societally-oriented academic carries out both basic and applied research. Like the Mertonian-oriented academic, s/he sees interaction with industry and involvement in commercialisation as a threat to the university's autonomy. The academic entrepreneur carries out both basic and applied research but does not regard the linkages with industry as a threat to his/her scientific work. The ensuing analysis aims at empirically validating these four academic types and orientations to market demand.

The organisational responses to market demand are analysed according to a two-group categorisation. The 36 university units studied are grouped into two categories, according to their research orientation with respect to intertwining academic and practical goals. The academically-oriented units include those university departments and centres whose emphasis is on basic research and/or teaching, reflecting the Mertonian conception of the academic role. The second group, the "market-oriented units", includes university units that have adopted the goals of integrating teaching, research and market-oriented activities (commercial or societal) under a broader institutional mission. This categorisation turned out to be more suitable for characterising organisational diversity than the four-quadrant typology. One reason for using two-group categorisation is that changes in organisational level may take more time than changes in individual behavior. Furthermore, there are likely to be various types of academics in the same organisation. From the analytical viewpoint, convergences and divergences become more evident when making a distinction between academically-oriented and market-oriented organisations.

The grouping into the two organisational categories was made using the following three criteria: 1) the institute's activity under the EU framework programmes, 2) the funding received from industrial funding sources (Tekes or companies); and 3) their success in achieving basic research funding or

competing for centres of excellence. The description of the two groups is shown in Table 5. The quantitative data is based on 1999 annual reports.

Academically-oriented institutes include university units with emphasis on teaching and basic or applied research. Altogether, 14 units from the total sample were grouped into this category. The concept of science implies that the main role of the university is to produce new scientific and technological knowledge and provide a highly educated labour force. The main characteristics of this category are the emphasis on the traditional academic values and roles, a minor success in raising industrially relevant research funding (Tekes, EU and private companies), the small size of the research personnel and lots of graduate-level educational responsibilities. The most common institutional form was the department.

Table 5. Characteristics of surveyed university units.

	Academically-oriented institutes pursuing basic or applied research	**Market-oriented institutes with aim to pursue simultaneously academic and practical goals**
Number of Units	14	22
Of which were centres of excellence	12 of 14 units	9 of 22
Organisational form	14 departments	14 departments 8 research centres
Graduate schools	2 independently 10 jointly	10 independently 9 jointly 3 no graduate school
Funding from Tekes	3 of 14	19 of 22
Funding from companies	4 of 14	17 of 22
Funding from EU	7 of 14 (amount of funding was very small)	All
Average share of external research funding	38%	58%
Size of the units in terms of personnel	11 units < 100 2 units > 100 < 200 1 unit > 300	11 < 100 17 < 100 >200 4 > 300
Disciplines	6 Natural sciences and technology 3 Biosciences 5 Humanities and social sciences	10 Technology and natural sciences 10 Biosciences 2 Humanities and social sciences

Market-oriented units represent units with a research approach aiming at combining academic and utilitarian (business or societal) interests. This group consists of 22 university institutes that demonstrated market-oriented approach with emphasis on integration of the scientific and business/societal values. Eight of the institutes were research centres, which did not have obligatory graduate-level education duties. However, all of them provided postgraduate-level education. In addition to research and education, the role of these institutes was broadened to include the fulfillment of different utilitarian goals – economic and societal. University institutes in this category have been the most active in the EU framework programmes. They had also had a large number of industrial and Tekes funded contracts.

It is worth noting that the larger number of units in this second category is partly explained by the sample choice. The involvement of units in the EU Framework Programmes was one of the main criteria adopted. The university units that are active in the EU framework programmes are of course likely to conduct research with an applied and practical focus. These examples are not intended to be exhaustive in representing the total population but the aim is to depict some institutional and cultural attributes that can be related to the adoption of a market-oriented approach within the university. It is to be noted that both categorisations (individual and organisational) are conceptual tools to identify the characteristics and impacts of entrepreneurial university and thus needs to be regarded as ideal models.

5.2 Incentives and constraints

The policy attempt to modernise universities, eliminate inefficiencies and improve accountability, competitiveness and an appraisal of interdisciplinary research were commonly recognised in both groups. However, the way in which the university institutes have dealt with these developments varies. When comparing the two groups, it emerges that university faculties and institutes with an emphasis on traditional scientific values more often seem to face declining support for their research activities and anxiety about future research funding. In contrast, the market-oriented institutes have managed to increase income from different sources, in particular from the EU framework programmes. Apart from fundraising strategies, the interview analyses seem to point to differences in the

new organisational form and management, and the adoption of interdisciplinary research approaches as the success factors (the differences are discussed in more detail later in the present chapter).

The literature identifies two broad motivations for university interaction with firms. The first is the financial incentive; the second is access to research material and new equipment (Zeckhauser 1996; Cohen et al. 1998; Faulkner & Senker 1995; Webster 1998). Several drawbacks to university involvement with industry have also been identified, such as the diversion of faculty time and effort from teaching as well as the conflict between industrial trade secrecy and traditional academic openness (Hall et al. 2000). In the following, the motivations of Finnish university researchers to collaborate with industry in EU-funded projects and their views on universities' engagement in commercialisation of research will be analysed.

5.2.1 Motives: Why collaborate with firms?

Collaborating with industrial partners in EU projects was only weakly related to the goal-setting of university participants. Figure 6 shows that the business-related output (software and prototypes) and resource-related objectives (such as the joint use of equipment and cost savings) were emphasised more often by those university participants who collaborated with firms than by those with no industrial partner in the project. Overall, very few university participants sought direct commercial benefits, or the opportunity to take part in commercialisation through the EU project. Only a third of those university participants who collaborated with firms in EU projects said that they sought the opportunity to take part in commercialisation.

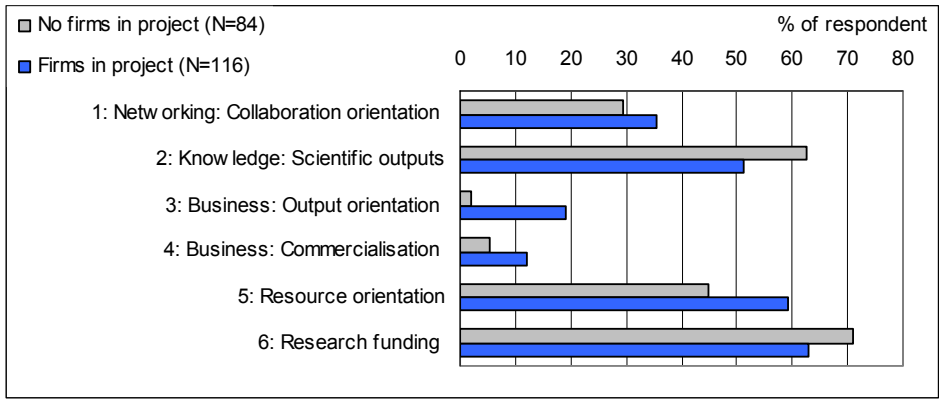

Figure 6. Goal profiles for university participants in the FP4 by type of consortium. Share of respondents who considered the objectives to be of importance (percentages). Survey 2000. The figure is based on average percentages of the answers that indicated that the goal items included in each factor were important or very important (or only ticked).

Table 6 suggests that university-industry collaboration in EU projects are strongly financially based, giving further empirical support to earlier findings (Zeckhauser 1996; Cohen et al. 1997). Apart from seeking funding for research, university researchers were looking for opportunities to apply their theoretical knowledge to the solution of practical problems, and to gain access to new research material. One-fifth of the university participants in the FP4 said that there was no particular reason for establishing a linkage with industry.

Table 6. Reasons for university collaboration with firms in FP4. Share of university respondents who fully or partly agreed with the statement (percentages). Survey 1999.

	Share of university respondents %
Funding	65
Opportunity to apply one's own theoretical knowledge to solving practical problems	49
Opportunity to obtain research material	33
Opportunity to take part in commercialising the results	28
Opportunity to learn about developments in the field of study	26
Partners were involved in the same project; there was no particular reason	20
Opportunity to use advanced research equipment	9
	N=82

A pragmatic academic approach to university engagement with firms was often reflected in the interviews. Many university researchers who had collaborated with firms confirmed that financial incentives were the main motivation to establish the linkage with firms. The linkage with firm partners had been established only because the EU funding directions insisted on it. Hence, for these academics, the linkage with firms was more or less instrumental – a vehicle to obtain further funding for research in constrained financial circumstances.

All in all, the findings from the interviews with the university staff support the conclusion that department leaders tend to be more interested by the growth, prosperity and institutional reputation of the organisation. Conversely, university researchers seem to be more influenced by academic reputation and prestige (see also Slaughter & Leslie 1997; James 1990). Most interviewed university leaders thought that collaborative arrangements with firms or other actors utilising research may bring prestige and visibility to the institute. Prestige seeking is closely related to the growing importance of international collaborations.

European-wide collaborations were deemed important because they open up a pool of expertise that is lacking in Finland. An interviewed unit leader describes the importance of a two-way research exchange as follows:

"International collaboration is growing rapidly. One indication of this is that foreign researchers are coming to our unit ... instead of our researchers leaving for foreign countries. This is one sign that our work is successful. EU collaboration has opened our researchers' eyes to look for options other than America." (Department leader / Microbiology)

This in turn may help them in obtaining more public and private research funding. Co-operation with firms also plays an important role in legitimising the operations of the research unit. Appreciation of the industrial research project is pointed out in the following quotation where a department leader describes the brighter side of the partnership:

"It brings in money, but that is not the primary reason for collaboration. The unit gains acceptability, it [collaboration with firms] strengthens and legitimises the existence of the unit. It also strengthens institutional self-respect." (Department leader / Biology)

In contrast with the pragmatic academic orientation to market demand, academics with an entrepreneurial approach saw the collaboration with firms as a mutually beneficial relationship. They thought that both universities and firms can benefit from the collaboration and that academic and commercial goals can be intertwined. For these academics, industrial collaboration had opened up a new array of opportunities to test their theoretical knowledge and offered a source of new research ideas and topics. In particular, some professors said that collaborating with industry provides a totally new context. It leads to conducting academic research in which the intellectual challenges are very different from the situation when they collaborate with partners who possess a similar background. They also appreciated the fact that collaborating with firms provided them with the opportunity to expand and diversify their own research career and apply their own expertise more extensively.

The above findings support the view that collaborating with firms may contribute to a new theoretical and conceptual understanding and thus provide returns in terms of scientific progress and contribute to enlarging the stock of knowledge. This is consistent with earlier findings suggesting that the

relationship between research productivity and commercial activity can be complementary (Mansfield 1995; Zucker et al. 1994; Thursby et al. 2005). Mansfield's (1995) study of 321 academic researchers found that faculty frequently worked on basic problems suggested by their industrial consulting. Similarly, Zucker et al. (1994, 1998) found that the most productive scientists in biotechnology often start new enterprises while continuing research in their academic appointments. Thursby et al. (2005) has showed that, with or without licensing, and regardless of the research production functions considered, faculty devote more time to research early in their career, so licensing does not alter their life cycle patterns.

Overall, very few university researchers viewed the collaboration with firms as detrimental to their research. Some reactions to university engagement in industrial-driven research were, however, defensive in tone. Reflecting on the Mertonian academic approach, some interviewed professors feared that university engagement with firms may potentially corrupt some core academic duties, thus causing the university to lose control over them. Another threat was the negative impact of collaboration on the quality of academic research.

The fear of losing their autonomy, and of the incapability of simultaneously carrying out educational and commercial duties, hindered the universities from collaborating with firms. Collaboration with firms was often based upon the research unit's resources and its capacity to meet external requirements. As a matter of fact, prior research has shown that a good international reputation and previous experience from industrial collaboration positively influence the university units' involvement in EU collaboration (Niskanen 2000, 2001; Geuna 1998). Interviews with Finnish university staff revealed that greater activity in EU collaborations derives from the following institutional qualities:

- Recently founded research centres seemed to provide a more flexible organisational environment for entering the EU programmes.

- An interdisciplinary approach and a wide pool of junior and senior researchers were emphasised as requirements for entering EU collaboration.

- A new management culture: the leadership in the unit seemed to play a particularly important role in encouraging international and industrial activities.

The organisational and cultural factors that favour or constrain the adoption of an entrepreneurial role will be discussed in more detail in the latter part of this chapter, which focuses on the impacts of the growing entrepreneurial and market orientation within universities.

5.2.2 Commercialisation dilemma

In the past, university researchers have left commercialisation of their research results to firms. Today, university researchers seem to be more willing to take part in commercial activity, as well as working with licensing firms during the development phases (see, for example, Niskanen 2000; Agrawal & Henderson 2002; Jensen & Thursby 2001), in order to also benefit economically from this activity.

The present study investigated university perceptions about the needs and threats of the university's engagement in the commercial utilisation of research results. Table 7 presents university researchers' views regarding the commercialisation of research results.

Table 7. University views on the commercialisation of research. Share of respondents who agreed with the statement (percentages). Survey 1999.

	No firms in consortium %	Firms in consortium %
The university should create explicit rules regarding the commercialisation of research results.	65	56
Researchers lack the special skills needed for commercialisation.	63	65
Researcher's participation in the commercialisation of research is considered positive by the university management.	58	56
The prejudices of the university researchers towards the commercialisation of research results have decreased.	43	46
University researchers' engagement in commercialisation decreases the reliability of university research.	25	30
The university should give more support to researchers participating in commercialisation.	25	37
Participation in the commercialisation of research results causes problems in one's educational work.	15	27

A large majority of university respondents agreed with the view that university scientists often lack the specific skills needed for the commercialisation of inventions. The majority was also of the view that the university should create explicit rules regarding the commercialisation of research. Over half of the university staff thought that university management sees researchers' participation in the commercialisation of research results as positive, reflecting the entrepreneurial approach and growing strategic importance of responding to market demand. Support declines, however, when it comes to increasing university services targeted at the commercialisation of research. In general, most university researchers were satisfied with the availability of present

services targeted at commercialisation. However, some criticism was directed at the low market competence of the service officers within the university. Although these services as such are abundantly available in most Finnish universities, more tailored and research-specific support for patenting and other commercial activities was requested. This includes the identification of new inventions that have commercial potential, definition of the commercial value of inventions and the search for international customers in those areas with no domestic beneficiaries.

The researchers' entrepreneurial approach towards commercialisation was only weakly related to their experience with firms. However, university researchers who had collaborated with firms were more often concerned about the negative effects of university engagement with commercialisation than the researchers with no such linkages. They also thought that the university's engagement in commercialisation might impede the reliability of the university's research and the university itself and that the university should provide further assistance to researchers' participation in commercial activities.

It was commonly perceived by the interviewed university staff that awareness of the significance of the commercialisation of research results had increased, at all levels. Sometimes this led to a situation in which universities and their researchers are no longer willing to give up their property rights to companies without any compensation. Instead, scientists and research units are seeking new ways to profit from their inventions. Pursuing commercial endeavours – be they patents, start-ups, or consulting arrangements – revealed both concerns and positive responses among the interviewed scientists. Very few were strictly against the idea of a commercial endeavour.

Primarily, there were two types of negative reactions. Firstly, some university researchers shared the belief that university research could be corrupted and that the openness of the academic community could be damaged. These scientists appealed to the Mertonian principles of science in pleading for openness. They also asserted that scientific research should always be based on openness, especially when it is financed through public funds. The following quotations illustrate the tensions arising when a university engages in commercialisation, reflecting the confrontation between the traditional Mertonian concept of academic work and the entrepreneurial ethos:

"In the old days, the top groups were a lot more open… everyone tried to discuss in order to stimulate each other and get ideas. Nowadays, if the issues are really "hot", people tend to hide their information until it is published or patented." (Professor / Science of nutrition)

"I consider commercialisation a great problem, especially because of the secrecy involved; there's a scientist in the next room and he has assistants who do not tell anyone what they are doing. It feels strange. It is a very peculiar situation at a university, especially in terms of the atmosphere. Then there are these restrictions on publication, which I think is very sad if the research is conducted within the premises of the university and the financial contribution of the university is big, for example employing a person, and then nothing is published. There will be no scientific publications on the basis of which the activities of the unit are measured. There will be no benefit for the unit. I made a decision long ago that I will not direct any Master's thesis that is not going to be published. Keeping the results secret is extremely unethical." (Professor / Science of nutrition technology)

In line with previous findings (Tuunainen 2004, pp. 31–32; Pelkonen 2001; Ylijoki 2003), the Finnish universities are not being directly transformed into an entrepreneurial entity but face tensions and problems in intertwining commercial tasks with research and teaching. Sometimes, the pursuit of an academic entrepreneurial role may face considerable institutional resistance. This arises in connection with the perceived societal role and ability of the university to sustain its focus and direction in the context of a global knowledge economy and a competitive research environment.

A second stream of negative attitudes revealed concerns about the time spent on commercial activities (see also Ylijoki & Mäntylä 2003). Engagement in commercialisation may move the research focus onto secondary issues, as interviewees with the conventional academic approach describe:

"The incredible amount of work in comparison to the money received. There is just no sense in it any more… you have to do such a great number of totally secondary things for it." (Professor / Biochemistry and food technology)

"I think that the university has a clear function in our society and it is to produce new knowledge and dissemination of research in society. I don't understand why we should become consultants and entrepreneurs. And how can we find time to do everything? I am not sure that one is able to do good research and other things at the same time." (Professor / Food technology)

A particularly difficult issue was considered to be the fact that the commercialisation of research results leads to unnecessary doubts, because university researchers are accustomed to publishing their work. In practice, this is not always true. Instead, universities have a lot of research projects in which confidentiality of information is agreed on with the customer. Jointly funded research is one grey area in which nobody seems to have a clear grasp of the operating principles. In terms of the internal integrity of universities, clarification of the guidelines and rules governing commercialisation is the most urgent task in order to avoid accusations of misappropriation of research funds and resources.

Completely opposite reactions characterised those university researchers who advocated a greater financial independence for the university. These scientists were frustrated by the deteriorating financing situation of universities. Partly as a result of that, they had attempted to promote the commercialisation of their results in order to obtain further financing for their research group. The following quotations support the adoption of entreneurial attitude and the claim that university researchers are increasingly operating like independent entrepreneurs within the university, thus carrying a lot of financial responsibility for procuring funding (see also Etzkowitz 2003):

"I get hardly any money from the university. They consider me a firm. It's no use fighting for university money. It's much more useful to gather one's own money. Money is not a problem in Finland. It's more a question of where to find talented scientists. Another problem is the fact that we cannot expand freely and employ persons at our own discretion within the university even when there is money available." (Professor / Medicine)

"The benefits of research are draining from universities to companies. This is partly because researchers do not think [of the risks] and they are too naive in their collaboration. Then the partner quickly takes the benefit and obtains the patent. The other reason is because commercial companies draw up agreements in which you lose as soon as you sign it. Researchers should develop their research to a certain phase, and then negotiate with a strong partner, not alone by themselves." (Professor / Medicine)

The interviews also brought forth views according to which the researchers felt that, in general, much more could be commercialised at universities than is done at present. The obvious threat that could result from preventing the participation of researchers in commercialisation is that the most innovative researchers might

move inside the companies, and completely sever their relations with the university.

"For us, the worst case scenario is when researchers notice that this is the start of a good business and abandon the university, simultaneously cutting off all relations." (Department head / Information technology)

Although many interviewed social scientists and humanists found the concept of "commercialisation" peculiar for their field, some of them thought that their research could be commercially utilised. Instead of commercialisation, these societally-oriented academics preferred to use the term 'productisation' of research results to describe the utilisation of research results in their own field. Examples of products of research in the social sciences and humanities that were mentioned included training and expert services, learning materials, assessment criteria, new working models and expert services (for instance for the media). A social scientist interviewed described the product development of his research as follows:

"A model of how social work is able to participate in the physical process of construction planning and implementation, for example … or production of a list of criteria that, from the social work perspective, are socially sustainable criteria for the environment." (Professor / Social sciences)

Besides the Mertonian and entrepreneurial academic approaches to commercialisation, a pragmatic approach to market demand emerged from the data. The pragmatic approach rested on the view that basic research can create applications but special skills and expertise are needed in order to commercialise them. The strategy adopted here is to leave the commercialisation to firms. The following four quotations highlight the pragmatic approach to commercialisation:

"We have several projects with companies that are worth millions and will last for several years. The scale is wide and their effect remarkable. Some master's theses and doctoral theses will result from these projects. Then there will be patents, but not too many, and they will be sold directly to the companies. Collaboration with companies is reflected in teaching as well. We know what the companies need and where they are going." (Department leader / Information technology)

"We have produced all kinds of CD-ROMs and books and different kinds of materials. They are sold through various organisations. We cannot sell them from our department

directly. We use some other organisation that takes care of this commercial side. In order for us to commercialise, we would need a more concrete effort, at least from the administrative side. There are also risks, of course. It is not unproblematic and it will not be possible for us to begin [to sell products] without a fuss." (Research scientist / Safety engineering)

"Basic research is one and the same; and it can create applications. It would be essential to see the possibilities for applications of basic research. It would be very important to have a unit at the university that could assist in this. It is obvious that university research is definitely not an expert in commercialisation. The whole legal process concerning commercialisation requires very sophisticated special expertise." (Professor / Medicine)

"We would rather see the best research results end up in industrial use than choose an entrepreneurial partner capable of commercialisation. We are just one link at the beginning of the chain and the firms handle commercialisation" (Department leader / Information technology)

To summarise, funding is not the only driving force for university-industry collaboration, but there is an increasing willingness, among scientists, to accelerate the transfer of knowledge and to bring research results to the market (see also Vavakova 1995, p. 581). Collaboration with firms has undoubtedly increased the awareness of the potential commercial benefits that university researchers might obtain. Nevertheless, almost all of the interviewed Finnish academics felt that they lack the competences needed for commercialisation. In addition, the existing commercialisation support services were considered insufficient and clearer rules for taking part in commercialisation in the university context were called for. The scientists also noticed some negative impacts on the university's autonomy deriving from commercial engagement. Due to the secrecy and lack of openness involved, the university's engagement in commercialisation is likely to raise internal tensions among academics with different attitudes towards entrepreneurial activities. Consequently, this may have a disruptive influence on the integrity of the scientific community.

5.3 Collaborating with firms: practical patterns

When examining the nature and success of university-industry interaction, it is fundamental to consider the problems encountered in these linkages.

The ‘spider’s web’ figure illustrates the percentage frequencies of problems for each problem category by consortium type (Figure 7). It shows that the views of the university participants with or without relationships with firms differed in only a few respects. University researchers who had collaborated with firms in the project encountered problems with respect to their partners’ varying know-how, cultural differences in communication and changes in the partner’s objectives more often than university researchers who had no industry collaboration. There is no doubt that academics’ awareness of the pitfalls and problems in collaboration with industry has increased. Most university researchers shared the view that the situation with regard to collaborating with firms has changed remarkably in the past decade:

“At first we were very naive. Ten years ago it felt great when someone gave us funding. None of us noticed the terms written in “small print” in the contracts. None of us realised that publishing these [results] would be forbidden. Now we are more cynical, more careful and more informed in every respect. We also teach these things to students.” (Interview 11 / Research scientist / Applied chemistry)

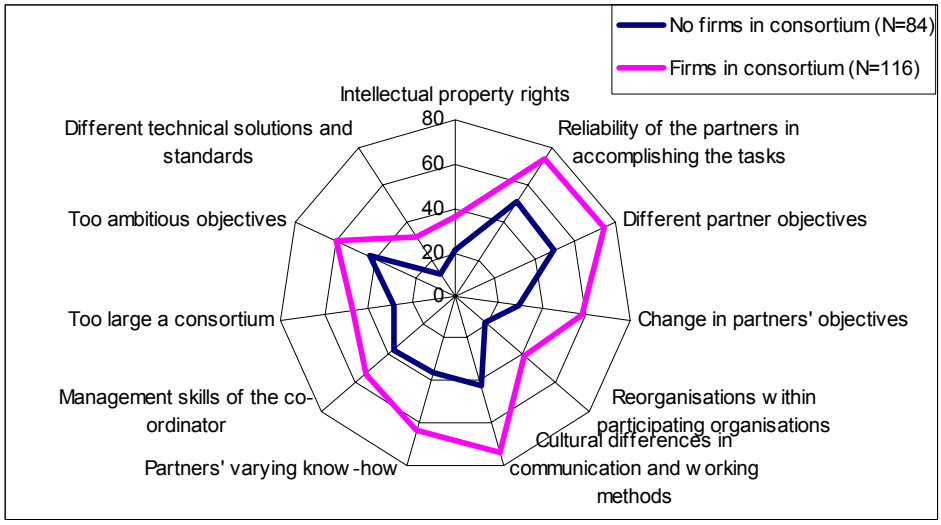

Figure 7. Problems encountered by university participants by type of consortium in the FP4 (percentages). Survey 1999. Percentage shares have been calculated taking account of the respondents that had at least some problems.

Understanding the partners’ intentions, expectations and working methods is the first step to successful collaboration. Even though co-operation with firms can

lead to a wide variety of problems, university researchers felt that they have learned from these situations. This accumulated experience should help them to avoid these same problems with firms in the forthcoming projects. Conflicts of interests can sometimes be serious and are only partly grounded on the weak regulation of commercial activities. In fact, university interviewees see no simple solution to the problem faced by university researchers engaged in the commercialisation of research. Finding the appropriate solution is often a case-specific issue and depends upon the amount of benefits, as well as the negotiation skills and closeness of partners.

The formation of a partnership between academic scientists and firms is related to the development of research activities, the construction of the content of the research, and the object of application. The interests and actions of the partners in the research project decisively influence the research content and application object. The essential process in the formation of a partnership is the definition of the research objectives and the inclusion of both scientific and business interests. The findings from the interview data indicate that potential problems may derive from the inclusion of both scientific and commercial goals, but that these problems can be solved. As expressed by the university researchers, dealing with research objectives in collaborative projects is by and large a question of negotiation: namely, how to articulate the content of research and how to market their own ideas to other partners.

A psychologist, who could be classified here as a societally-oriented academic, explained that the content of research is dependent upon how strongly the scientists themselves contribute to define the research targets and how the division of labour between research organisation and firm is negotiated. She argued that:

"There is no democratic discussion and decision-making but they [researchers] have to tell the others [industrial partners] what they want to do and how they will do it. Then the project can be marketed to firms and a project set up which would respond to the demands and concerns of firms." (Professor / Psychology)

She also noted:

"Earlier they [scientists in her unit] had been prejudiced against collaboration with firms because they feared that firms would restrict their research and dictate what to do. As

their experience of industrial collaboration increased and the firms began to appreciate their expertise, their attitudes became more positive towards industrial collaboration and commercial utilisation of research results." (Professor / Psycology)

Another university researcher having an entrepreneurial research approach reported her experiences with two different types of firm. In the first case, the firm had set clear targets for the research project and they worked closely together to carry out a project responding to the demands and concerns of both scientific and business parties. During the project, it appeared that the firm did not need the application that was initially set as a goal of the project. The firm wanted to change the initial objective of the project and the university partner was asked to solve a new research problem. In this case, the scientist was given full support to reorganise her research project. Even though the first project did not yield any concrete new production processes, the firm was nevertheless satisfied with the outcome of the collaboration, and it has since contracted smaller projects from the university laboratory.

In the second case, the same university researcher collaborated with a firm that had no concrete ideas of what they actually needed or expected from the project. According to the researcher, the firm participated in the project only because it wanted to follow the technological development in the field. In this case, the university partner could not obtain any intellectual contribution from the firm, only funding. After the project ended, the partnering firm criticised the university counterpart for not producing any valuable result for the firm.

These comments imply that when the research plan is defined well enough, it allows each partner to carry out the activities that they would do anyway. Thus, the planning of a project linking a university and a firm is a typical bargaining process that aims at finding compromises between the different goals and also at justifying the significance and utility of the project to financiers. Setting clear and concrete targets for collaboration as well as the partners' commitment to these targets are essential preconditions for successful collaboration. These findings are in line with Fujimura's (1996) suggestion that if task–person and task–organisation relationships are clearly established, then the work of designing who should do which task is already done or reduced. She also argues that a clear division of labour reduces political and organisational uncertainty (Ibid. 1996).

It has been argued that scientists may try to make their work appear more applied research-like and observe a particular style in order to obtain more resources when circumstances are constrained. Calvert (2002) uses the concept of "tailoring" to describe the scientists' reactions to demand to demonstrate the potential utility of their research. She argues that scientists' "tailoring" has shown that external pressure on scientists does not necessarily have a predictable impact on research practices. Scientists are actors who react to pressures on the basis of their perceptions, values and interests, rather than in a predictable or mechanical way. This "tailoring" work was also reflected among the interviewed Finnish researchers.

"Personally I have felt that they [participation rules] are just formalities. Good research proceeds in that direction which makes sense. Even though the research plan says that we are going to do it [research] in this way and the milestone will be this, and soon we recognise that it was a good plan, we change the plan and follow a new direction. Of course I hope that the EU staff will not get angry... Anyway these formalities have not restricted me in carrying out research if I do not obey them." (Professor / Medicine)

This finding further supports the previous evidence that when scientists are compelled to take on industrially-oriented funding, they change their conception of the situation in order to perceive themselves as persisting in a familiar basic research activity (Campbell & Slaughter 1999). The lack of a common understanding of the research content was an often-mentioned factor that may hinder success in university-industry collaboration. That firms and academic partners do not have the same educational background is an element likely to cause problems in collaboration.

Another factor that influences the success of science-industry collaboration is trust and openness between the partners. Trust between the parties is considered of particular importance when there are intellectual property rights to share. One clarifying comment on this was made by a university professor. She regarded her industrial partners as companions. In her mind, the linkages with industry could best work as a way to obtain professional assistance in IP issues and to further develop new research ideas:

"Initially I had a research idea that was supported by the Academy of Finland. The project produced some astonishing results that I could not understand – they were totally unexpected. Then one firm came along. That firm saved me because the funding provided by the Academy was not sufficient to carry out an analysis of the results. I

applied for funding from a private foundation, and when I had received funding twice from it, I went to tell them [the firm] about the results. They became interested in the results and suggested that we could extend the project further and patent the results. I received all kinds of practical help from them and they never tried to take the property rights away from me. ... When it comes to making an invention, there seems to be a problem in that major research financiers don't want to take great risks. Normally, if you propose a crazy plan, you will never get funding for your ideas. However, I would never have invented these things if I had done things like they used to be done." (Professor / Agriculture and forestry)

In accordance with the suggestions of Owen-Smith and Powell (2003), this type of collaboration helps universities to patent and, in particular, to identify and file high-impact patents. The research collaboration within the EU framework programmes has thus brought scientists and entrepreneurs together. Scientists have learned something about the specific needs of industry, but also to detect the commercial value of their results and gradually adjust their own demands to the process.

The comment below, by a university researcher, shows that the ownership of research results can be perceived very differently from the way their industrial partners do. Different rules apply to academic and industrial ownership:

"Sometimes industrial partners may think that they own the bacteria [the result of the research] and that it is better not to tell anyone about it if it later turns out that the bacteria cranks out some poison ... because it can be bad for businesses ... they [industry] think they own it [the results] but we think that no one owns it." (Professor / Microbiology)

For this academic, the academic openness and visibility of the results is highly important. The credibility of the results regarding the production and articulation of knowledge requires the results to be available to the scientific community. According to Lynch (1985, p. 264), "what counts as a notable finding, a definitive anatomical entity, a thing's attributes, a procedure of measurement, an adequate display of data, and a plan of methodic action" is secured through interaction with others. Institutional relations within a university facilitate this process and require scientists to engage in academic production to secure the research status for themselves (Packer & Webster 1996). Undertaking research in a firm context cannot be easily mapped into this institutional setting. A scientist may find herself in an unpleasant confrontation when trying to balance the distinct institutional and market demands. Moving out of these two worlds

and crossing up the boundaries can often be problematic. It usually requires a range of socio-technical competencies that do not exist in the current academic community.

Taken together, the above findings regarding a university's involvement in commercialisation provide a somewhat ambiguous picture. While the survey results imply that the problems encountered in the collaboration with firms are not perceived to be considerable by most university researchers, the interview findings point to the opposite outcome. From the viewpoint of the survey data, few problems encountered in science-industry collaboration suggest that problems are not insuperable as has been commonly presumed. Alternatively, the survey respondents may not have been willing to report their failures to outsiders, but preferred to give an impression of successful collaboration for one reason or another. One interpretation could be that collaboration between university and firms has not taken place in any tangible manner, but linkages have been rather formal and instrumental in obtaining research funding from the EU. The overall impression gained from the interviews is that both parties do what they would do anyway, and a sole commitment to joint goals is lacking. This raises the question of whether there genuinely is a market demand for collaboration, or if EU funding only supports formal alliances and substitutes for cuts in public research funding.

It is obvious that collaborating with firms and universities' involvement in the commercial utilisation of research results are likely to raise complex problems. These problems are neither easy to solve, with any standard solution, nor avoidable with any formal contract procedure. If anything, the conflicts of interest rest in the internal logic of commercialisation of research results. All parties engaged in the commercialisation of research results can expect to achieve some benefits – be they material or immaterial. Achieving a win-win situation in the distribution of benefits accruing from collaboration is unlikely to be achieved if neither party is willing to make concessions.

Evidently, both parties need special capabilities to absorb different types of knowledge in order to avoid conflicts of interest and understand the specific needs of their partner. For university scientists this may mean that they should look beyond their original disciplines and absorb the practical reasoning of the firm. Industry engagement in the project does not necessarily mean that

university researchers have to give up their own principles. However, it is important to be guaranteed a good negotiation position, to pursue their own objectives and to have freedom in carrying out the project. In this way, the research itself can proceed in a natural way and the academic targets can ultimately be achieved.

5.4 Outcomes and impacts of the research collaboration

From the perspective of the effects on university practices and research, collaborating with firms and the engagement in commercialisation can be characterised as direct or indirect. Direct effects can be new knowledge and methods, publications, patents, products and research quality. Indirect effects may relate to the cultural and institutional characteristics of the university.

5.4.1 Achievements of the EU projects

Some university researchers were asked to estimate the achievements and impact they had already obtained and still expected within the next three years. Those university participants who collaborated with firms in the EU project were perceived to have obtained benefits associated with knowledge less often than those who had no such linkages (Figure 8). Instead, university researchers collaborating with business partners emphasised having commercially-related results (e.g. obtaining IPRs) more often than the university researchers with no such linkages (Figure 9).

Overall, the results and outcomes obtained from collaboration unveil the research orientation of the project. If firms are involved in the project, the project is more likely to aim at commercial ends. Hence, it is evident that these projects may be more applied research-oriented than the projects with no firm linkages. With respect to the commercial outcomes of EU projects, some interviewed university participants were clearly very critical. In particular, they doubted that the large size of the consortia would be attractive from the firm viewpoint and this might not produce direct commercial results. However, one element seems to be clear. The more application-oriented and closer to the

market the EU project is, the more likely that conflicts of interest in sharing intellectual property rights appear.

Secondly, both the survey and interview data highlight the achievement of scientific and technological outcomes. The linkage with firms has not hindered universities from achieving knowledge-related results, or publishing the results. As it emerged from the interviews, writing scientific publications and articles is more often restricted by a lack of time than by the firms' interest in keeping the project results secret. When academics make the decision to engage in an industrial-oriented project, they need to be aware that publishing the scientific results may be constrained by time shortages.

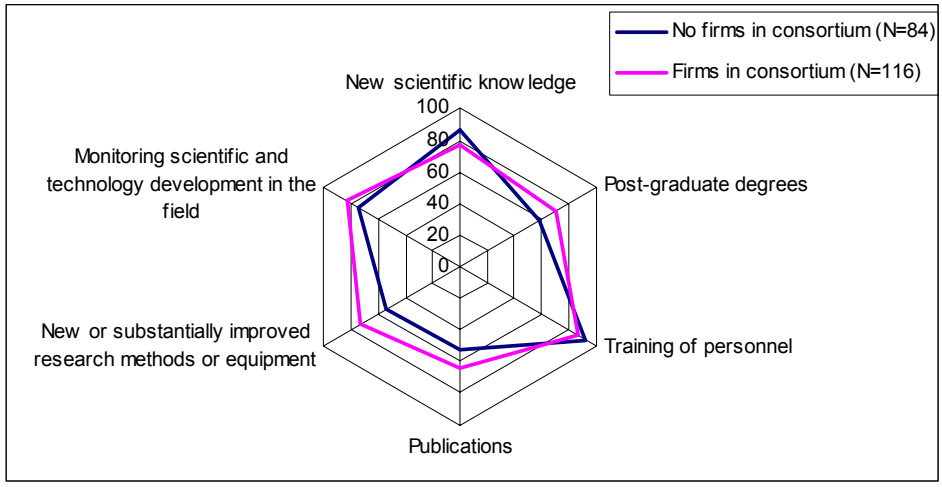

Figure 8. Achieved and expected knowledge-related results as viewed by university participants by type of consortium in FP4 (percentages). Survey 1999.

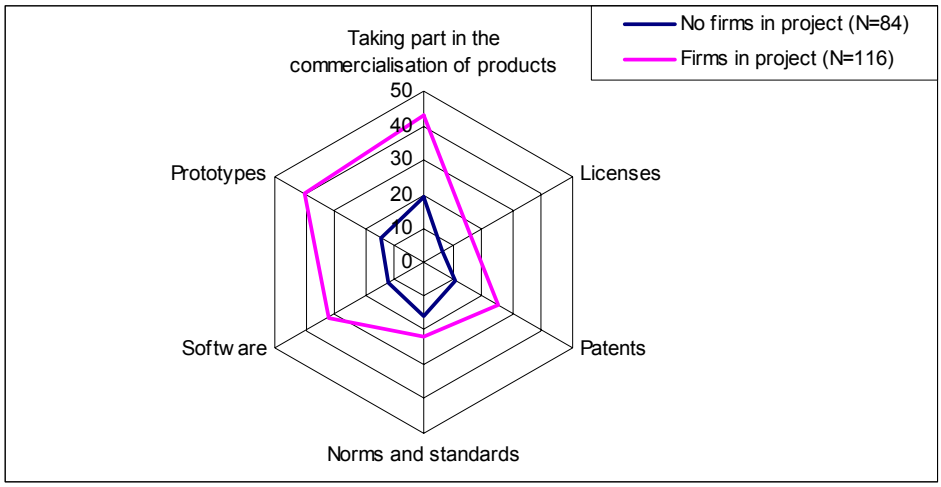

Figure 9. Achieved and expected commercial-related results by type of consortium as viewed by university participants in FP4 (percentages). Survey 1999.

Thirdly, the results also somehow indicate that research collaboration between universities and firms, within the EU framework programmes, are formal in nature. When the linkage is established only for financial reasons, both parties may pursue their own goals. Unfortunately, the survey or interview data does not provide enough evidence about the depth of university-industry linkages. However, these observations open the way for further research in two directions. Firstly, a deeper understanding of the operation of the university in a commercial context and its influence over the scientific work is needed. A second important research path to pursue could be to obtain a better understanding of the ultimate economic impacts of longstanding collaboration between universities and industry on technology transfer, the commercial utilisation of academic research and the innovation activities of firms.

5.4.2 Strategic importance and effects on research quality

A university's perception of the strategic importance of the EU projects and their effects on quality were examined in order to capture the significance of the indirect impacts of university-industry interaction. The quality aspect deserves special attention, because of the assumptions that interaction with industry can be detrimental to the quality of academic research and to the advancement of

knowledge (Ziman 1994; Feller 1990). Despite these fears, there is no strong evidence to support the view that engagement in commercial work damages the quality of research or leads to compromised research objectives. On the contrary, literature points to the conclusion that entrepreneurial activity has been a concomitant feature of the origin of university (Etzkowitz 2003). Likewise, it has been suggested that research excellence and innovation can be firmly linked and when mediocre research is supported, neither science nor innovation is likely to gain much direct benefit (Hicks et al. 2000).

The above claims were tested in this study by asking the university researchers to indicate whether the project they had carried out was of strategic importance, supported other research activities or was of marginal importance. In general, the proportion of projects of "marginal importance" was quite small and the majority was of potential future importance or supported other research activities of the university participants. With respect to the strategic importance of the EU project for universities, the results indicate that no major difference exists between those who collaborated with firms and those who did not. This implies that the research projects that envisage the participation of firms can be useful for university researchers.

From a university viewpoint, the two surveys concerning the Finnish university participants in EU FP4 provide conflicting results with respect to the impact of partnering with firms on the research quality of the EU project. In the survey conducted in 2000, quality was less frequently regarded as being of high international standard in cross-sector consortia rather than in consortia with no firms. Data from the 1999 survey provided opposite results concerning the effect of collaboration with firms on the research quality of EU projects. As viewed from the university perspective, the collaboration with firms had no notable influence on the research quality of the EU project.

This view was also supported by the academics interviewed. Nevertheless, some university participants complained that the participating firms do not often put their best experts and brains into the EU project but rather use the projects in order to educate their junior staff. According to one academic this leads to mediocre research, which lacks the novelty and risk-taking elements.

"Research is conducted for the needs of bureaucracy when scientific goals have a minor role. There is no room for seeking new knowledge, but the research is more like remodelling and applying existing knowledge in a new form." (Interview 14 / Researcher / Applied chemistry and microbiology)

Figure 10 shows the overall benefits of EU collaboration, as viewed by university participants by type of consortium. Overall, the university participants without firm collaboration more often perceived various benefits accruing from their EU project. Earlier evidence from the framework programmes has shown that the EU projects are heterogeneous in nature. Most typically, these projects are described as longer-term, of potential future importance, applied research-oriented and collaboration-oriented (Niskanen 2001; Luukkonen & Hälikkä 2000; Kungliga Vetenskapsakademien 1999). However, the academic research quality of EU-funded projects raises some doubts among university participants, as shown by the survey results. The firm involvement in the EU project makes it more likely to lead to a qualitatively different outcome than the cases in which they are not involved. The EU projects where firms were involved produced fewer benefits related to strengthening international collaboration, publications, broadening the knowledge base, providing new funding channels, providing training opportunities for young researchers or objectives related to basic research.

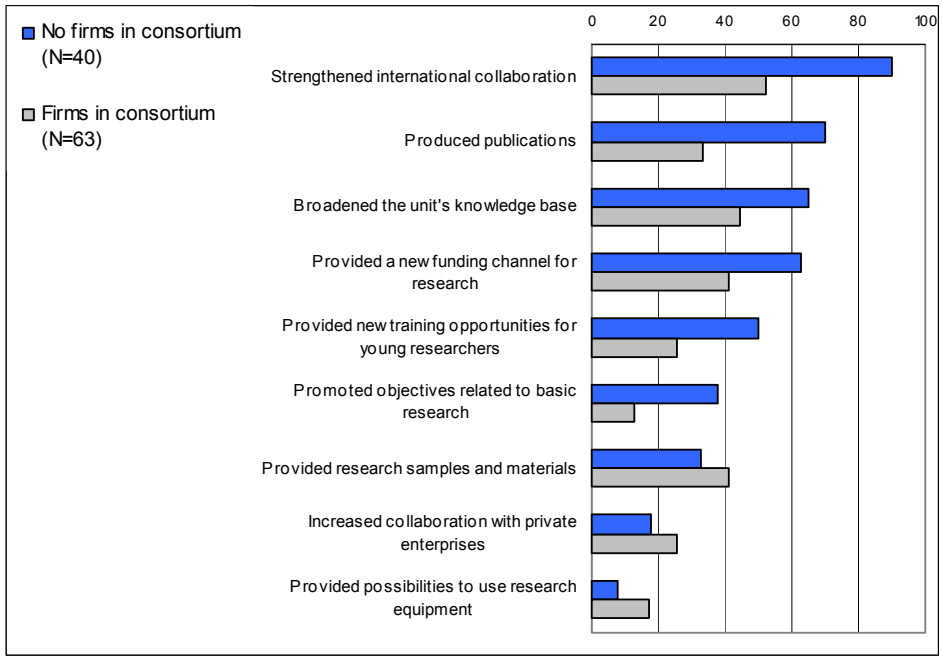

Figure 10. The benefits of the EU R&D framework programmes for the research conducted in the unit (percentages). Share of university respondents who agreed with the statement. Survey 2000.

The interviewed heads of units held different views about the effect of industrial-oriented research funding on a university's research and research quality. However, they saw the long-term effects to be obvious. Academically-oriented units were more often concerned about the fact that industrial-oriented research funding might weaken the handling of teaching tasks. In some cases, funding intended for teaching purposes was used to cover research costs. In market-oriented units (those institutions that had succeeded in obtaining external research funding), some researchers argued that good relations with the business world and funding from companies are necessary for researchers to be better aware of their practical needs.

"Otherwise, there won't be any relevant research topics, because researchers could select any molecule they like and spend their entire life studying this single molecule" (Research scientist / Applied chemistry and microbiology / Interview November 1999)

It was argued that industrial funding is only a problem for institutions when it is sought opportunistically, without a clear research purpose and objective. The maintenance of a specific research profile was seen as a guarantee that the institution will be competitive in the future as well. If the institution would not invest in long-term basic research, it would soon have no new competences to offer. There was, however, no direct indication of such behaviour that institutes or researchers opportunistically pursue external funding without considering its suitability to their own research focus and strategy.

Evidently, further empirical evidence, based on objective evaluation measures, is needed before making any judgement about the influence on research quality of the firms' engagement in the project. However, with this argument in mind, it seems that EU projects are heterogeneous in nature and their quality varies. At best, these projects may pursue new knowledge and bring new innovations, while at worst, they produce self-evident results and statements resulting in neither scientific nor socioeconomic benefits.

5.4.3 Increasing competitiveness

It has been recognised that EU research collaboration is a cumulative process (see e.g. Luukkonen & Hälikkä 2000; Niskanen 2001; Peterson & Sharp 1998). EU participation seems to be related to scientific productivity. For instance, Geuna (1998) has shown that scientific productivity is related to both the probability of joining an EU-funded research project and the number of times an institution has participated in these projects, while research size has a positive influence only on the latter. Hakala et al. (2002) have argued that developing international collaboration with well-known universities also means establishing a positive and augmented image and prestige for the institutions involved, and is one of the main incentives for co-operation.

Since the work of Merton on the Matthew's effect (1968), it has been recognised that the organisation and resource allocation structure of science tends to reward successful individuals and groups with access to means that increase their propensity of being successful in the future. Thus, the highly selective and competitive nature of EU funding may send a signal to other potential financiers about the university units' quality and confer a halo effect on winning units and

projects, thus boosting the chances of a unit's success in attracting additional funding for its R&D activities.

According to Geuna's (1998) study on university participation in co-operative R&D projects funded by the European Commission, early entrants tend to have advantages in their later participation. Further, in the UK, for large departments, EU funds seem to be accompanied by substantial funds from the national government whereas smaller sized departments suffer from funding substitution. Owen-Smith and Powell (1999) have suggested that the shift in the university mandate, from public to private science, has consequences for the funding of university research. This may have effects on the competitive relationships among universities where commercially focused research selection processes move universities away from traditional peer-reviewed funding sources. Success depends increasingly upon institutional reputation. They also argue that besides increasing stratification in science funding, increasingly close relationships between universities and firms are breaking down the distinction between private and public science. Hence, universities that develop effective patenting and licensing practices have a relative advantage over those that do not strengthen their pattern of cumulative effects.

University researchers were asked whether EU funding had facilitated receiving additional research funding from national sources and whether that was considered acceptable. The views of university researchers on this question are presented in Table 8, by whether the respondents had participated in EU projects or not.

Table 8. University views of the effects of EU participation on research fundraising (percentages). The percentage of respondents who agreed with the statement. Survey 2000.

	EU participants % (N=103)	Non-EU-participants % (N=86)
EU participation has a positive influence on receiving funding from own university.	31	38
EU participation facilitates funding from national sources.	56	66
EU participation should not have any effect on how national research funding is appropriated.	50	59

EU funding seems to increase the likelihood of attracting additional external research funding, but only to a limited extent. Over half of the university respondents thought that EU participation facilitates funding from national sources. Non-participants believed so more often than participating university respondents. These findings do not fully support the view that EU collaboration provides a financial incentive that confers a halo effect on winners, as has been suggested by Geuna (1998). The assumptions that EU funding augments the probability of attracting other funding and, in turn, leads to the concentration of resources in a few institutions produced both supportive and contrary arguments. On the one hand, the concentration of research resources was seen as a necessary step in creating a critical mass in research and success in international competition. It was noticed that a small country like Finland cannot be internationally competitive in a large number of research fields. On the other hand, focusing resources on a few groups or on a relatively few fashionable research fields may prevent the breakthrough of new talents and fields, if the selection criteria are based only on earlier performances. Some university researchers were worried about the fact that concentration of research funding would lead to a neglect of research topics of national importance or fields that are not easily commercially exploitable.

As shown in Chapter 4, the Finnish higher education funding structure has gone through some marked changes in recent years. As a consequence, the competitive character of university funding has reached a steady state. Throughout the 1990s, universities were also restructured in ways that put new pressures on their institutes.

In fact, the market-oriented groups, in particular, stressed the importance of competitiveness and accountability. The distinguishing feature for this group was that they seemed to have adopted a more centralised fundraising strategy than the academically-oriented group. The responsibility for financial management was often centralised at the corporate level, where support services and specialised functions (e.g. marketing and human resources) were managed as overhead costs. Both senior and junior researchers participated in the preparatory phase, although seniors took the responsibility for the final negotiations. In the market-oriented institutes, junior researchers were often exempted from taking care of administrative duties, so that they could concentrate on long-term projects, or writing their thesis, without worrying about where their salaries would come from. In contrast, obtaining external research funding in the academically-oriented institutes was the responsibility of established staff, treating them almost as if they were self-employed.

University leaders in the academically- and market-oriented units admitted that the strong competition for research funding among rival colleges and institutes creates a powerful incentive for each institution to try to match or exceed its rivals. Nevertheless, this development was also seen to have some counterproductive effects. There were three different kinds of observed difficulties. First of all, the increasing difficulty for universities to conduct long-term and scientifically challenging research. According to those interviewed, fewer and fewer university researchers dared start bold research projects and initiate extensive and demanding research activities that attempted to solve scientifically difficult problems. Secondly, the majority of university researchers criticised the fact that the greater the number of senior professors and researchers, the less time there was for research, due to the increase in managerial and administrative duties. A professor from an academically-oriented institute describes the accumulation of managerial responsibilities for senior staff in the following way:

"Our weakness is that everything lies too much on the shoulders of a few persons. We do not have enough critical mass to form a shelter for know-how. I am easily overburdened because I should be able to give advice to everyone at the same time. In research, it is quite a risky situation when someone becomes irreplaceable." (Professor / Applied chemistry and microbiology)

Actually, time appears to be a scarce resource for an increasing number of scientists in managerial positions. This, in turn, is likely to reduce the contribution of senior scientists to scientific advancement. However, in order to be internationally productive and competitive, the scientific enterprise needs professionally and technically trained people. Hence, a significant motivating factor could be lost if the most promising and creative scholars cannot contribute to scientific research and cannot receive public recognition for their achievements.

A third implication of the increasing competitiveness in fundraising is that universities can only provide scientists, in Finland, with less promising and permanent career opportunities. One interviewed department leader from a market-oriented unit describes the worsening career opportunities in universities as follows:

"Our problem is that the best students go to the top American laboratories for their post-doc period and when they come back to Finland – often with great enthusiasm and new ideas – we have nothing to offer them except short work periods. I regard this type of behaviour as an unbelievable national economic wastage." (Professor / Medicine)

The above finding suggests that the current policy pays too much attention to educating a large number of researchers, while the quality aspects of the research training and basic research are neglected. Evidence from this study shows that, although the research funding system has been increasingly market driven, university scientists seem to be confident of their academic freedom and feel that traditional values have not been destroyed and few problems have arisen as a result (see also Hakala et al. 2003; Nieminen 2005; Häyrinen-Alestalo & Peltola 2004). It must be noted that the desire for universities to be more commercially important does not necessarily imply these as being commercial per se. Benner and Sandström (2000) discuss the emergence of a new organisational field that is a hybrid of traditional academic research and the knowledge-based economy, combining collegial recognition with entrepreneurialism and societal

accountability. They also suggest that this new model is based on academic autonomy and initiatives taken by university research, but, at the same time, efforts are made to direct academics to operate with industry (Ibid. 2000).

5.4.4 Organisational diversity as a strategic asset

The increasing collaboration and university engagement in commercialisation have affected not only the individual performance of academics but also the performance of the research organisations. One of the major differences was the way in which the studied university institutes were structured and pursued the inter- and multidisciplinary approach. Compared to the academically-oriented units, often made up of several science groups and divisions, the entrepreneurial-oriented units consisted more often of heterogeneous disciplinary groups designed to pursue the unit's research agendas. These institutes had also taken advantage of the restructuring to better match the changing research environment. The main reason for establishing new research units was to secure reliable resource streams in a period of economic crisis. One head of a research centre describes the funding situation in the mid 1990s as follows:

"The rationalisation of university institutions was a big step in a better direction. Most of these new research units created totally new contacts with companies and other users. We were living in the middle of an economic depression and the struggle for the university's own research funding was fierce. In that situation we were forced to seek funding from outside ... like companies, Tekes and the EU." (Department leader / Technology)

In particular, heads of new research centres perceived that the new institutional form had provided better facilities, larger research teams and more external funding, which in turn helped these institutes to operate in increasingly fiercer competitions. Also, the research centre model had enabled these institutes to transcend the traditional disciplinary boundaries and bring together a new mix of people whose synergy enabled them to solve new problems in unconventional ways. The following quotation by the head of a recently established research centre describes the advantages of the interdisciplinary approach as follows:

"Recently, we have realised that the fusion of small units and an enlargement of the science base created synergies that made solving topical practical problems in our unit easier than in conventional departments. Our strength is currently based on the fact that

we can carry out both basic and applied research. One thing is that we should avoid having too homogeneous a group of researchers." (Research centre director / Information technology)

Thus, the reformation of Finnish universities and establishment of new multi and interdisciplinary research centres in the 1990s can be seen as a structural response to external demand, i.e. bringing science closer to the marketplace and making it more useful for the economy. The new hybrid-like research groups and interactive research practices are most likely to be found in engineering and natural sciences (Nieminen & Kaukonen 1999, 2004; Nieminen 2005; Häyrinen-Alestalo et al. 2000).

Scientific heterogeneity was positively associated with respectively, success in fundraising and the adoption of a market orientation. The divisional barriers that formerly cut across the institute were removed, so that the entire organisation could operate as a unified entity. Some interviewees, however, commented that diversity of research might become a disadvantage if it disperses the cohesiveness of the research group and the research focus. This fear is supported by Jaffe and Lerner's (2001) findings that laboratories that have pursued unfocused diversification efforts may have lower quality research. If diversification reduces quality it may lead to less knowledge transfer and spillovers. In a study of more than 1200 American universities, companies and government laboratories, Bozeman (2000) found that the strongest predictor of technology transfer participation was having diversified research missions. Those research institutions which were narrowly focused, regardless of the nature of the focus, were less likely to be engaged in technology transfer than those laboratories with diverse, multiple missions.

The growth of the multi- and interdisciplinary approach was seen as part of the development that is related to the external urge to harness research to the needs of economy. The changes in the university structure indicate the need for further collaboration and interaction between research groups across departments, both within and amongst universities. Lee (1999) identifies some important factors for interdisciplinary collaboration. While the research centre size, the level of administrative integration and funding support are strongly associated with the potential for interdisciplinary collaboration, the establishment of interdisciplinarity as a mission of the research is likely to enhance the extent of

interdisciplinary research carried out. An applied research orientation, along with a substantial presence of professional staff, also encourages interdisciplinary activity. Disciplinary and faculty structures, however, are likely to be major barriers for interdisciplinary research.

Interdisciplinary research can be both endogenous and exogenous to the scientific realm. According to Schmoch et al. (1996), interdisciplinary research can be looked at from the perspective of a discipline-bound scientist who struggles with a specific problem. To solve this problem, academics search for some help from other disciplines. In this case, an interdisciplinary behaviour aims at improving the scientific advancement of a specific discipline. When the evolution of social needs requires greater interdisciplinary research, it can be considered exogenous to science. As science took on the role of a general problem-solver in the twentieth century, it was expected to deliver solutions to society's important problems. The range of these societal problems, however, stretches far beyond the borders of a single scientific discipline. Taking into account the distinctive paths of interdisciplinary research, two notions can be made. From the viewpoint of academic institutions and scientists, the incentive to pursue interdisciplinary research may be based on the assumption that interdisciplinary research is vital in order to move on in one's own scientific work, where the main discipline is not able to offer the most effective tools. Pursuing interdisciplinary research can be seen as instrumental to gaining access to research funding and to achieving own research career's goals.

In Finland, a multi- and interdisciplinary approach to research is most clearly concretised through the establishment of new research schools. Compared to the academically organised research training within a single faculty and discipline, establishing new postgradute schools within the new research centres was seen as an efficient way to deliver interdisciplinary postgraduate degree courses. The doctoral schools have been fostering the establishment of contacts between the students engaged in the doctoral programme, but belonging to different research areas. It has also been attempted to create some interaction between research groups and disciplines, thus creating additional opportunities for interdisciplinary research. Furthermore, the EU framework programme concept was regarded as an important policy instrument in facilitating interdisciplinary research and research training. EU collaboration had especially benefited young

scientists who could acquire new professional skills and qualifications by collaborating with top European scientists (see also Niskanen 2001).

However, the combination of groups and units and the reorganisation of institutions had, in many cases, led to internal problems and conflicts. Indeed, in these restructured units each research group struggled to gain resources in order to develop its own research area. They competed directly with one another for the institutional resources, such as technical services and funds for research equipment. Some interviewees felt that the regrouping and centralisation of activities were threatening, especially to their own autonomy in conducting research. The reorganisation of institutions had also significantly increased the bureaucracy related to handling internal matters. One negative development was considered to be the fact that researchers' desire to help their colleagues by, for example, reading and commenting on research results had decreased as a result of increased competition and work pressures.

One market-oriented institute had had a somewhat different experience. In this institute, the members appeared to divide themselves into several rather separate scientific groups. Even though these groups did not share a common background, they all worked in a common, shared laboratory space. There were also attempts to create further collaborations across the scientific borders, through a regular series of seminars where the senior professors and post-graduate students, who worked in the different research groups, could meet and discuss the prevailing and future research and scientific strategies.

In terms of the institutions' success, internal competition was considered beneficial and essential for the institution to keep up with the progress and remain at the forefront of development. According to the researchers, mutual competition had created a new kind of dynamics and "entrepreneurial spirit" within the institution. Only continuous competition between researchers can keep research vigorous, one interviewee said. However, the simultaneous scientific and commercial success of the institution had led to new problems, which the institution had not prepared for in advance. Some researchers felt that the workload of directing and assisting foreign researchers and research students was too large. In such cases they were left with too little time for their own research.

5.4.5 Towards an entrepreneurial type leadership and research culture

Evidently differences exist in the leadership and management patterns of the academically and market-oriented university groups. It has been argued that leadership has a growing importance in contemporary universities and public research organisations (Cohen et al. 1999; Kankaala et al. 2004). For instance, in Weick's (1995) view, an organisation's leaders are the sense-givers of the environmental change. The importance of leadership in the transformation of universities has also been confirmed in the study covering the UK research establishments (Cohen 1999, p. 244).

When comparing the perceptions of the two groups, it clearly emerges that the leadership and management of research activities in academically-oriented units were most often left in the hands of individual professors. Leadership was often almost absent. These units were less likely to have a clear research mission. Further, little evidence emerged about the department functioning as a unified entity. Of course, there were also exceptions to this, but the strategies used by the heads of departments focused on maintaining and improving the department's status and resources. Market-oriented units deemed to have been more successful in adopting well outlined strategies for dealing with research activities and administration and their tactics presented a more business-like management than academically-oriented institutes. Nevertheless, both conventional and business-type leadership were present in market-oriented institutes.

Furthermore, the interviewed director of the market-oriented institutes tended to be personally more aware of the competition, external demands, expectations and collaboration. They concentrated more on making their institutions more dynamic and internationally acknowledged as well as on generating increased profits than their counterparts in the academically-oriented group. The adoption of a business-type leadership and business management culture, as well as the importance of maintaining and improving the units' economic and human resources, and international status were emphasised.

University researchers were not always so sympathetic towards the attempts to unify the units' strategies toward market demand and, occasionally, the attempts to harmonise the activities in the department through strategic work were

contradicted by the staff members. On the one hand, some academics complained that their unit was administered in too much of a top-down manner. They feared losing too much of their personal freedom and decision-making with respect to research and the selection of their own research topics. On the other hand, the leaders' example and encouragement seemed to have had a strong influence on the research content, the institute's success in fundraising and their involvement in commercial activities. The effect of this encouragement was especially apparent if the researchers considered participating in the commercialisation of their research results, or even carrying out entrepreneurial projects of any kind. Many researchers felt that they needed the background support of the organisation leader when seeking to commercialise their research. Correspondingly, the leaders' strong negative attitude was considered to be a significant obstacle in terms of seeking to exploit the research.

It seems that the universities' hierarchical decision-making system is now being challenged by internationalisation, financial pressures and the emergence of new technologies. Institutional survival and prosperity of the university seems to be increasingly dependent upon the leadership and the capability to build and lead productive and creative research groups. The view that research groups have firm-like qualities and that groups are run like small businesses, especially under conditions in which research funding is awarded on a competitive basis (Etzkowitz 2003; Hakala et al. 2003), also gets support from this study. Universities are adopting working methods typical for the business world, as the bureaucratic way of carrying out research cannot respond to the knowledge demands of businesses.

Evidently, there is a connection between high levels of management commitment and the capacity to sustain the utilisation of research results. The market-oriented approach to research calls for a new managerial role from senior scientists. It means making contacts with financing agencies, industrial firms, obtaining research grants for the department, negotiating the terms for the exploitation of research results, appointing staff to research projects, and ensuring that research projects are completed on time (see also Ziman 1994; Slaughter & Leslie 1997; Nieminen 2005). It also calls for a dynamic research environment that results not only from the daily interaction between the scientists, but also from an inspiring spirit, where all are encouraged to do the best research possible and publish in the most appreciated forums.

6. Role of universities in industry's R&D

The previous chapter highlighted the diversity of university approaches to market demand and their entrepreneurial role. Cultural and organisational factors seem to explain the various frequencies of universities' engagement in commercial and entrepreneurial activities. Tensions also emerged from the attempts to combine scientific goals and market demand.

This chapter focuses on firms' views and experiences of collaborating with universities. The aim is to highlight the role of universities in technology development and innovative activities of firms. According to the economic rationale for university-industry relationship, universities are expected to contribute to the technological development and innovative activities of the firms. On the one hand this demand derives from the changes in nature of technological innovation itself (its growing complexity and dependence on science). On the other hand, this demand reflects the immediate economic pressures by the rapid internationalisation of industrial system. From the economic rationale, following questions arise: (1) which role do universities play in research partnerships with firms? (2) what are the major constraints, tensions and drawbacks of partnering with universities? (3) Do universities affect the development and commercialisation of industry's technology? (4) What is the significance of the EU framework programmes in promoting university-industry interaction? Answering to these questions would help to understand the real market demand and also to assess the policy measures intended to enhance the innovative activities of different types of firms, through university-industry relationships (i.e. large firms vs. small and medium-sized enterprises). The latter relates to the need for a systemic approach to public intervention. It stresses the need for policies to be suitable for the various parties in different systems of innovation. These can be notably different from each other, e.g. with regard to specialisation of production, resources spent on R&D.

The analysis of the firms' incentives and experiences of university collaboration are based on surveys among Finnish firm participants in the Fourth and Fifth Framework programmes. It is important to notice that the EU framework programmes cover such a diversity of activities that any assessment of the goals, achievements of the EU Framework Programme as well as any relations will inevitably simplify matters, to some extent. In addition, it is also to be admitted

that in Finland EU R&D funding through the Framework Programme for Finnish firms is on a minor scale. For instance, in 2002 the EU funding comprised only 0.6% of total Finnish firm R&D expenditure. Thus, the extent to which this input influences the firm's R&D activities is rather limited. Furthermore, keeping in mind the original objectives of the EU framework programmes, which provide funding for precompetitive research, measuring these impacts is a difficult task (see further Luukkonen 2003). What can be achieved is a rough evaluation of the general effects and indirect or spillover benefits of university-industry collaboration within the EU framework programmes. Taking these limitations into account and keeping the nature of cooperation and time span firmly in mind, the following analysis, however, sheds light on the nature and significance of research collaboration between universities and industry.

This study pays special attention to the relationship between universities and small and medium-sized enterprises. In recent years, the creation of technology-based firms by scientists or graduates and the intensification of the interaction and co-operation between universities and SMEs have received increasing policy attention (OECD 2000, 2002a; European Commission 2003; Jacob et al. 2003). Start-ups and spin-offs are regarded as an important instrument for rapidly transferring new technological developments and innovative business ideas generated by science into commercial use. At the same time, given the increasing range and uncertainty of technological opportunities that companies must monitor, multi-technology firms see increasing advantages arising from outsourcing experimentation and testing to small, specialised firms, while maintaining in-house capacity for monitoring technological development. Consequently, it appears that the traditional direct links between large multi-technology firms and university-based research are increasingly mediated through small research-based firms (Pavitt 2001).

The expectations and experiences of small and medium-sized enterprises on university research are studied by conducting a survey among 98 Finnish innovative SMEs and interviewing four SME directors in 2003. The former was conducted in the year 2002 for the purposes of evaluating the Finnish innovation support environment (see Loikkanen et al. 2002; Ministry of Trade and Industry 2003). The majority of the surveyed firms are firms with a strong focus on innovation: 96% of these firms reported having carried out innovative activities. It is worth stressing that the survey data is not based on a statistically

representative sample. However, this data is assumed to catch the essential problematics, thus identifying the main elements of university-industry collaboration. Given that the survey does not offer sufficient information about the underlying motivations, interview data enables us to identify bottlenecks and best practices, helping to envisage the firms' expectations towards university partnerships. The interviews were semi-structured and lasted from 1–2 hours. The company directors were asked their views on the importance of collaboration with universities, requirements for collaboration and issues related to the securing of property rights. The four interviewed firms were as follows: Two of the companies were public research organisation start-ups having a knowledge-intensive business. The third was a fast-growing SME, targeting international markets, which spun off from a university research project. The fourth was a firm integrating a new technology into a traditional field.

When generalising the results shown below, the practitioners' views of the relevant outputs and of the technical and commercial success of the project may be weighted over the extent of their contribution, as well as the limited perception of the further innovation development, subsequent utilisation and market introduction.

6.1 Motives for university partnerships

In general, Finnish firms seem to look at European collaborations as a way to access complementary skills and knowledge. The firms who had collaborated with universities appreciated having access to complementary skills and knowledge and obtaining new contacts more often than the other firms. Collaboration also opens up new research topics. Partnering with universities is regarded as particularly valuable in achieving new contacts and opening up new research topics (Table 9).

Further information of the innovation needs of SMEs is provided by the survey data among Finnish SMEs conducted in 2000. SMEs were asked to assess the importance of the various factors that might enhance their competitiveness. Technological development was seen more often as an opportunity (87%) rather than a threat (37%) for the firm. The availability and persistence of a skilled labour force was assessed equally as an opportunity (45%) and a threat (46%).

From all the alternatives provided, the SMEs asserted the success in assessing economic risks, management of R&D costs, and internal co-operation to be more important than external co-operation for the success and competitiveness of the firm.

Table 9. What prompted firm respondents to take part in European collaboration in FP4. The share of respondents who agreed with the statement (percentages). Survey 1999.

	No university in consortium %	University in consortium %
Partners have complementary skills and knowledge	54	60
In order to obtain research funding	45	45
New contacts	36	58
European collaboration improves the reputation of the research group / own organisation	40	48
The research problems concerns several EU countries or the whole EU	30	31
European collaboration opens up new research topics	14	33
In order to obtain research equipment and material	14	27
European collaboration opens up new markets	43	40
In order to promote standardisation at European level	15	16
	N=94	N=181

Note. Percentage shares have been calculated taking into account the respondents that had given values 4, 5 or ticked. The scale: 5–1: 5 = very important, 1 = of no importance.

Table 10 shows that almost all firms assessed their R&D activities (90%) and marketing (89%) as important/extremely important for enhancing their competitiveness. The importance of co-operation with university and R&D organisations was ranked as being as important as co-operation with other firms (34%). Less than half of the SMEs assessed patenting and licensing as being important factors in influencing their future competitiveness. A comparison between the SMEs with or without collaborative linkage with public research organisations shows that the SMEs with such experience assessed more than on

average the firm's own marketing, patenting and licensing functions as important for the competitiveness of the firm.

Table 10. The selected factors supporting the competitiveness of small and medium sized enterprises. Survey with SMEs 2002.

		Meaningless or completely meaningless %	Fairly important %	Important or extremely important %	N
R&D activity of your firm	With university coll.	1.4	8.6	90.0	70
	With no university coll.	1.0	7.1	89.3	28
	Total	2.0	8.2	89.8	98
Marketing of your firm	With university coll.	0.0	2.9	97.1	70
	With no university coll.	10.7	21.4	67.7	28
	Total	3.1	8.2	88.8	98
Patenting and licensing	With university coll.	24.3	28.6	47.1	70
	With no university coll.	57.1	14.3	28.6	28
	Total	33.7	24.5	41.8	98
Co-operation with universities and R&D organisations	With university coll.	11.4	45.7	42.9	70
	With no university coll.	46.4	42.9	10.7	28
	Total	21.4	44.9	33.7	98
Co-operation with other firms	With university coll.	32.7	28.6	38.6	70
	With no university coll.	35.7	28.6	35.7	28
	Total	33.7	28.6	37.8	98
Availability of venture capital	With university coll.	31.4	21.4	47.1	70
	With no university coll.	35.7	14.3	50.0	28
	Total	32.6	19.4	48.0	98

The respondents were also asked to comment on the role of selected external co-operation as barriers to their success. The co-operation with other industrial sectors was most often mentioned as a barrier for the success of firm (30%). Only 16% of all surveyed SMEs assessed collaborations with university as a barrier to the success of the firm.

Overall, for SMEs, supply chain relationships seem to be of greatest importance as factors fostering to innovative activities and competitiveness. Nevertheless, collaboration with universities and other public research organisations not only increased expertise and technological development but indirectly augmented the general capabilities of the firm, including patenting and marketing activities. It emerged that innovative projects with a university may introduce the firm to new customers or new markets.

6.2 Sources of knowledge used by Finnish firms

The research base is today acknowledged to be a critical element of firms' innovation capacity. This asset is fed by the continuous interactions with external knowledge sources, such as universities and other public research institutions (Mansfield 1991, 1995; Tijssen 2002, 2003). This is more often the case in the new research-intensive sectors, like biotechnology, where the underlying science is extremely dynamic, and where the link between basic research and application has always been strong (Orsenigo et al. 2001). Prior work has shown that there are different types of knowledge exchanged in the innovation processes, and that there are differences in the effectiveness of various kinds of channels for exchanging the different types of knowledge (see Foray 1997; Gibbons et al. 1994; Lundvall 1992).

The relative significance of university research as a source of information was assessed in the survey of the Finnish participants in the Fifth Framework Programme. As indicated in Figure 12, the respondents had an overwhelming reliance on their own firm as a source of information (consistent with Cohen & Levinthal 1989; Faulkner & Senker 1995), followed by universities. Clients, suppliers and private sector sources of expertise – i.e., consultancies and private R&D service firms were among the least ranked sources within the EU collaborations. The relatively low use of clients and suppliers as sources of information may reflect a lack of their direct relevance in the early product development phase, although they are usually deemed to be significant sources of knowledge.

A similar trend is found when analysing the significance of various information sources contributing to the project outcome (Figure 11). The firm itself was considered as the most important one, followed by universities and public or private non-profit organisations. The significance of clients, R&D service firms, suppliers and competitors was again lower than universities. Some previous evidence points to the opposite finding, i.e. that public sector research plays a less important role as a knowledge source than a number of other sources such as competitors, contract R&D firms and joint or co-operative ventures (e.g. Cohen et al. 1998; Cohen et al. 2003). Nevertheless, the survey results do not necessarily imply contradictory evidence but may reflect the specific role of the EU framework programmes in the firms' R&D activity. Being engaged in EU

programmes may help firms to determine those technologies developed in the academic sector that could be of use for their own technology strategy later. It may also help them to keep abreast of external developments in the fields they are interested in, or to eliminate bad ideas, or to calibrate whether a particular technology is viable.

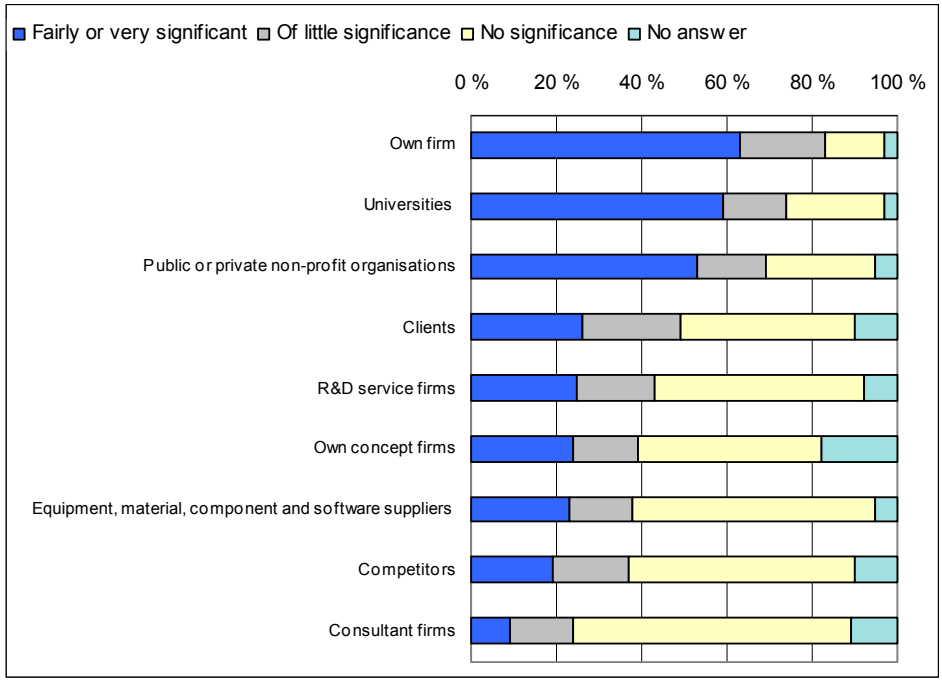

Figure 11. The significance of various information sources for firm respondents within EU FP5 (percentages, N=79). Share of respondents who regarded the source as of high importance. Survey 2003.

For comparative purposes, the firm respondents were asked to assess the significance of universities and public research institutes for their research and development activities. The 'spider's web' figure illustrates the percentage frequencies for each activity category by organisation type (Figure 12). It reveals that, in contrast with the assumption that universities conduct basic research and governmental research institutes tend to concentrate on applied R&D, the role of universities and governmental research institutes is remarkably similar from the firms' perspective. Both universities and governmental research institutes contributed equally as a source of knowledge to the core business or to the

activities that are close to the firms' core business. Both universities and governmental research institutes seem to have a modest role in developing commercial products. Also, universities and governmental research institutes were deemed to conduct similar types of research in the context of the EU projects, thus reflecting the blurring boundaries between these two public research organisations. The old division of labour between fundamental and applied or problem-oriented research is disappearing, and with it, the functional distinctions between universities and public labs.

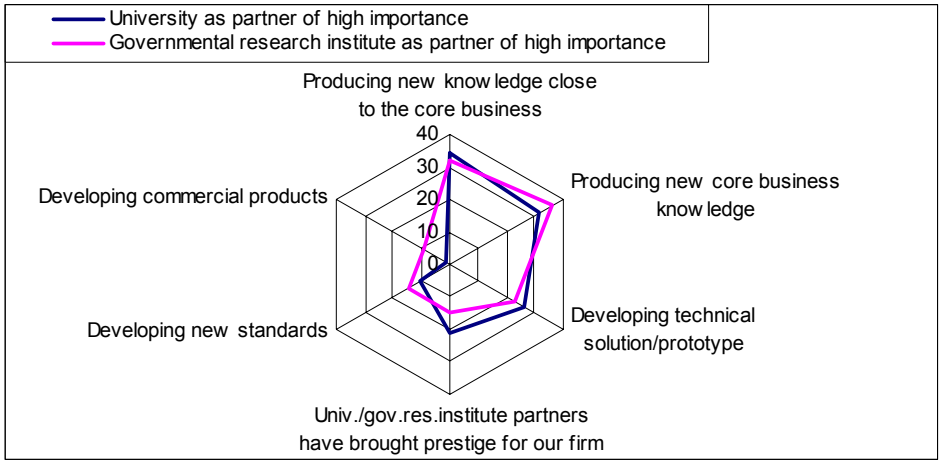

Figure 12. Significance of public research organisations for innovation activities in firms within EU FP5 (percentages, N=79). Share of respondents who regarded the source as of high importance. Survey 2003.

From the firm's perspective, the unclear division of roles between universities and research institutes can provide the opportunity for firms to establish competition between the various research organisations, for the same research projects. From the policy-maker's perspective, however, it is not efficient to maintain a two-level institutional research structure characterised by overlapping tasks.

The survey concerning the Finnish innovation environment provides further information on the significance of universities for SMEs. The SMEs were asked to assess the importance of the promoting factors and barriers for their innovation activities. In the questionnaire, *innovative activity* was defined as an

activity with the target of developing or introducing a new or remarkably renewed product or production process into the markets.

In relation to co-operation and networking with other partners in innovation activities, the SMEs considered collaboration with firms in other industrial sectors to be the most important external partners influencing their success (79%). The role of universities, research institutes and foreign partners scored as almost equally the same importance as co-operation partners (about 60%). Co-operation with universities and other public research organisations was primarily initiated by the firms themselves (83%), whereas only in 10% of the cases by the public R&D programme.

Figure 13 illustrates the SMEs' assessment of various information sources, by type of the relationship with universities or other public research organisations. All SMEs assess internal R&D activity to be the most important source of information (fairly and very important 95%). Highly important information sources are customers and suppliers (90%). Universities and research centres are also of fairly high importance (59%) as information sources, while licensing was the less important of the alternatives provided to the respondents (25%).

Those firms who had collaborated with universities and public research organisations tended to appreciate the recruitment of experts and patenting more often than those firms who had no such linkages. This suggests a qualitative difference among the surveyed SMEs. However, to evaluate the relationship between academia and the significance of patenting (as a source of information), as well as the SMEs' needs for their scientific and technological know-how, further empirical study is needed.

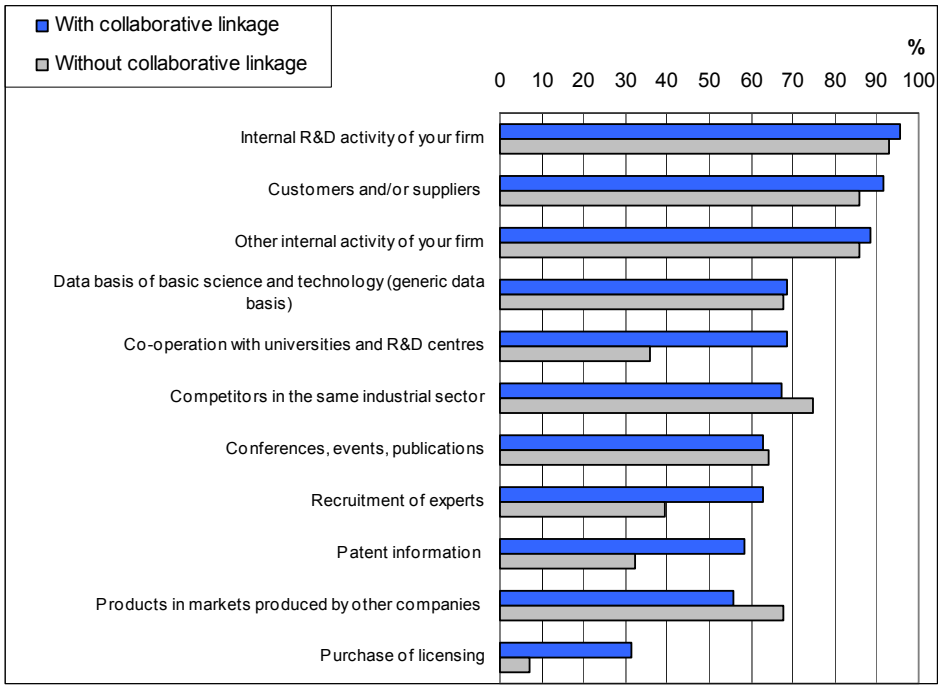

Figure 13. Information sources in enhancing the skills and knowledge of firms by firm type (with or without collaborative linkage with public research organisations). Share of SMEs who considered the fact as "important or very important" (percentages). Survey 2002.

In this respect, interviews with the managing directors of four SMEs provide further insights into the relevance of collaborating with universities and the public support for these collaborations. The common view among the directors was that the public infrastructure for R&D functions fairly well. In particular, Tekes contributions to promoting university-industry linkages were regarded as being of crucial importance. Some gaps were, however, identified. The interviewed directors were concerned about the inadequacy of the highly educated labour force in Finland. High competence was regarded as a necessity, especially for those firms seeking to grow in the international markets. Co-operation with universities and governmental research institutions is particularly emphasised in the activities of the firms operating in the global market. SMEs' opportunity to succeed in the global market is based on how capable they are to adopt and utilise new technologies. They cannot do this alone, though, but need

partners for support. The firms need both technology experts and customer firms as partners.

A director representing a firm that integrates a new technology in a traditional branch describes the growth prospects of the firm as follows:

"Now we have all the world's technology at our disposal and customer firms on the other side. We are the think tank in the middle that offers joint opportunities to those without such a link." (Director of SME in integrating new technology in a traditional branch)

Over a period of several years, the firm in question has created an extensive co-operation network with some Finnish universities in various research fields. In practice, the firm wouldn't even have existed without its network of university institutions, because its activities are mainly based on integrating new technologies in traditional fields. In another case, university collaboration, as well as publishing an article about an invention with university partner had provided the credibility to attract further funding and international customers.

6.3 Benefits accruing from university collaboration

From the industrial perspective, three questions are central when studying the benefits and outcomes of partnering with universities in EU projects:

1. Are there systematic differences in the research outcomes of the EU projects between universities that are involved and those that are not?

2. Does the universities' involvement in the project accelerate or hinder the development and commercialisation of technology?

3. Previous evidence has shown that larger firms tend to be more active than SMEs in the formation of university collaboration (e.g. Acs et al. 1994). Are large firms also more successful in generating direct and indirect results?

These questions were addressed by asking each participant firm to assess the outcomes of their EU research projects. The responses were divided into two

groups: with and without university partners in order to analyse whether the partnership with university affects the outcomes of the project.

The outcomes of the EU projects seem to differ in several aspects. Partnering with a university had a significant positive effect on the generation of knowledge (Figure 14), the added visibility and prestige of firm and networking (Figure 15). The greatest difference between university and non-university consortia was related to acquiring and assimilating new scientific knowledge and research methods and monitoring the scientific and technological development in the field. In terms of firm size, differences between the consortia were more substantial among small and medium-sized firms than among large firms. For instance, 18% of the SMEs without university partners in their project reported achieving new knowledge, while the corresponding figure for SMEs with collaboration was 60%. The corresponding figures for large firms were 34% vs. 68%.

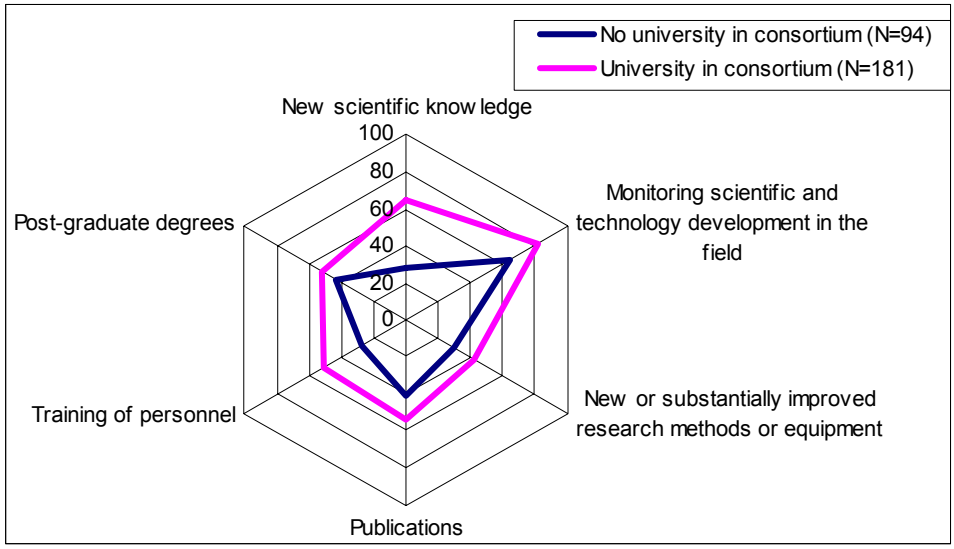

Figure 14. Achieved and expected knowledge-related results for firm participants in FP4 by type of consortium (percentages). Survey 1999.

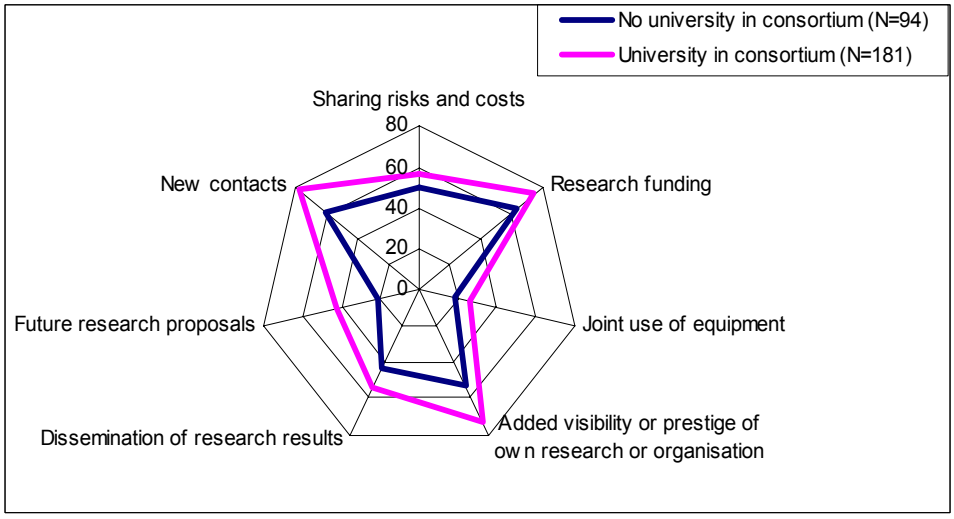

Figure 15. Achieved and expected networking- and resource-related results for firms in FP4 by type of consortium. Share of the respondents (percentages). Survey 1999.

The presence of universities in the project favours the production processes but hinders the creation of software, norms and standards. In general, though, the differences were minor (Figure 16). With respect to firm size, SMEs who had collaborated with universities reported more often than large firms (with the same status) having positive effects with respect to achieving goals related to software and product diversification. By contrast, large firms reported more often than SMEs a negative effect of collaboration with university with respect to achieving business-related goals related to the expansion of market and improved production processes.

It has to be noted that these findings are qualitative in kind. Prior research has shown that firm and business unit size explain very little of the variance in business unit R&D intensity. These findings do not, however, imply that the characteristics of firms do not affect R&D intensity (Cohen et al. 1987; Hall et al. 2000). More research is certainly needed with respect to the relationship between partnering with a university and the size of the firm, before inferences can be made.

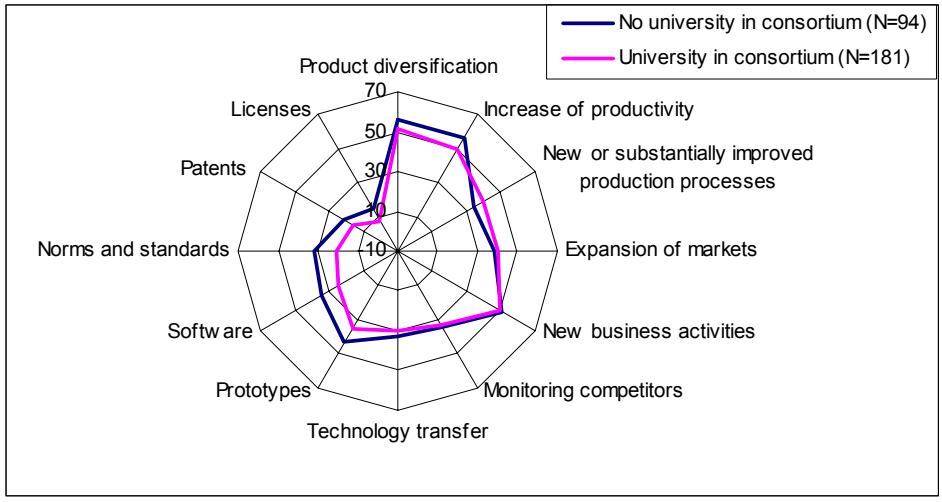

Figure 16. Achieved and expected business-related results for firms in FP4 by type of consortium. Share of the respondents (percentages). Survey 1999.

Consistent with prior work's findings (for example, Rosenberg 1992; Faulkner & Senker 1995; Cohen et al. 2003), the main contribution of university to

industrial R&D seems to be principally via research findings and training. Furthermore, this contribution is far greater than that of prototypes, new products, processes or other business-related achievements. These findings support previous evidence about universities providing research insights that are anticipatory of future problems more than the firm's own R&D functioning alone. Also, the linkage with university stimulates and enhances the R&D conducted within the firm (Rosenberg & Nelson 1994; Hall et al. 2000).

Based on evidence from EU collaborations and earlier literature, universities' contributions on industrial innovation seem to lie in four major areas. Firstly, knowledge, which is reflected by the emphasis on monitoring new knowledge in the field. Secondly, instrumental benefits, reflecting public research being of practical help and assistance (e.g. developing research methods to carry out new research and development projects in a new manner). Thirdly, the social dimension, which refers to the establishment of strategic networks, gaining access to major players in the field and gaining prestige. And fourth, commercial support, such as new products and processes, spin-offs, patents, licences. Overall, from the firm's perspective, university-industry collaboration seems to generate different types of benefits for the collaborating firms more often than projects where this relationship does not exist.

6.4 Project success

An interesting issue is the impact of collaborative linkage on the success of the project. In this study, the firms' representatives were asked to assess the success of their EU project. The results show that a relationship between the university engagement and the success of the project does not exist. However, when asked to elaborate in this respect, i.e. why the project was successful, the reasons differed somewhat by consortium type (Table 11). Those firms who had collaborated with universities in EU projects were more optimistic about achieving both technical and scientific objectives (than consortia with no university participants). As for the reasons why the project had been less successful, no differences emerged between those projects that involved universities than those without this linkage (Table 12).

Table 11. The respect in which the project was successful within the EU FP4 (percentage). Survey 1999.

	Firm respondents	
	No university in consortium %	University in consortium %
Learning new technical and scientific knowledge and skills	44	46
Learning to work in an international project	46	67
Achieving technical and scientific objectives	47	63
Succeeding in developing commercial products	14	20
	N=94	N=181

Table 12. The respects in which the project was less successful within the EU FP4 (percentage). Survey 1999.

	Firms	
	No university in consortium %	University in consortium %
Participants' commitment was weak	14	18
There was no concrete co-operation	13	12
Objectives were unrealistic	18	17
Objectives or end products were not achieved	9	11
The quality of research was mediocre	4	4
Some of the research problems were trivial	7	9
	N=94	N=181

Overall, it seems that the universities' engagement in the EU projects had only a minor impact on succeeding to develop commercial products. In the light of this study, the direct economic role of universities in firms' innovative activities and commercialisation of research seem to be exaggarated.

6.5 Problems in university collaborations

The university participants in the EUFP4 had not encountered major problems with their industrial partners. However, according to prior literature, there are reasons to believe that the cultural differences are likely to arise conflicts of interest between the two different organsisation. What did the Finnish firms think about collaborating with a university? Did the firms face problems when working with their university partners in the EU projects? Figure 17 illustrates the percentage frequencies of problems for each problem category by type of consortium. All other things being equal, firms that had collaborated with universities had systematically encountered more problems. There was about a fifteen percentage difference between the two classes in most problem categories.

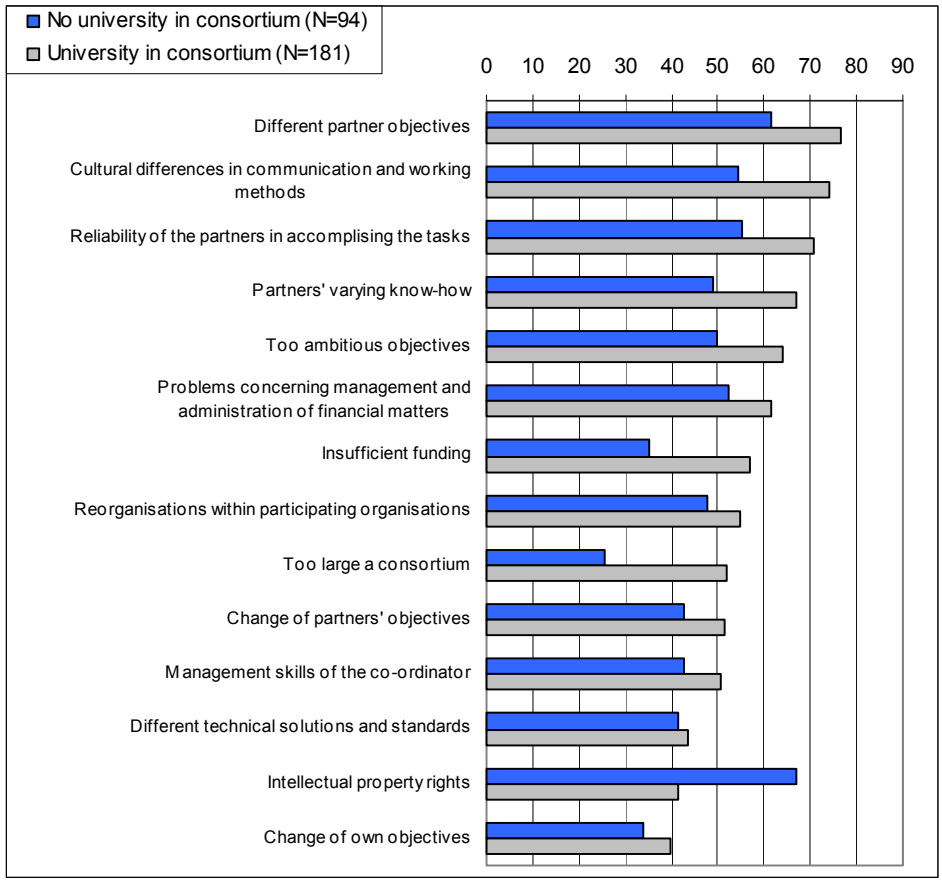

Figure 17. Problems encountered by Finnish firm participants in the FP4 by type of consortium. Share of respondents who gave values 2,3,4,5 or ticked (percentages). The scale: 5–1: a lot of problems, 1 = no problems at all. Survey 1999.

The greatest differences were related to consortia being too large and insufficient funding. Cultural differences in communication and working methods also seem to be a barrier for succeeding in collaborating with universities. The problems encountered by the firms mostly relate to the co-ordination of the work tasks, which are typical of research collaborations, not only science-industry collaborations. In comparison to the perception of a university's participants (see section 5.3), the firms having links with a university reported the occurrence of problems with respect to intellectual property rights less often than those with no linkage. This could be expected, as the intellectual property rights are of more strategic importance for firms than for public research organisations. The

primary reason for having few problems with sharing intellectual property rights may be due to the fact that EU framework programmes are geared to promote precompetitive research, the results of which are not necessarily and immediately commercially viable.

A possible explanation for the relatively few problems encountered in the university-industry consortia is that there has not been concrete interaction between the partners, meaning that they had never worked together or changed any information during the project. Collaborations are regarded as a formality to gain access to research funding. Some indications of the formality of the university-industry partnerships had already been expressed in the interviews among the university participants. University partners commented that they had never met their industrial partners. Firms were there only because it was easier to obtain funding for the project.

As protecting intellectual property is often considered a major problem between universities and industry, the relevance of the protection issue more thoroughly in the survey and interviews with the Finnish SMEs was investigated. Table 13 depicts the significance of the different protection methods for innovations, as viewed by SMEs. Being faster than the competitors and maintaining secrecy were considered to be the most effective methods of protection. However, more than half of the surveyed SMEs considered patenting and other legislative protection devices to be an effective means of protecting innovations. The comparison between firms with and without linkages with universities shows that the views of the SMEs in both groups are very much alike. The evidence gathered in this study confirms earlier findings. In many industries, firms rely predominantly on mechanisms other than patents to protect their innovations. Such devices are secrecy, first mover advantages and exploitation of complementary assets (e.g. sales and services) (Teece 1987; Mansfield & Lee 1996; Levin et al. 1987; Winter 1989; Arundel 2001).

Table 13. The views of Finnish SMEs on the effectiveness of the protection methods for the innovation (percentages, N=98). Survey 2002.

	Ineffective %	Fairly effective %	Effective or very effective %	Total (N=98) %
Patents and other legislative protection methods	12.2	22.5	65.3	100.0
Secrecy (non-disclosure)	6.1	22.5	71.4	100.0
Production and development activity supporting innovation activity	5.1	17.4	77.6	100.0
Services or other products completing or supporting innovations	10.2	26.5	63.3	100.0
Our firm acts faster than competitors	7.1	3.1	89.8	100.0

Rather than seeking the formal protection of inventions, SMEs seem to rely more on the commitment of their staff to achieve the firm's targets, offering them financial incentives to commit to the firm's success. The following interview quotation illustrates this basic pattern:

"This does not only apply to the firm's own staff; instead confidentiality in co-operative relationships is also a prerequisite for small firms to be able to commercially utilise the information they receive." (Director of fast-growth SME targeting international markets)

Even if they do not hold patents to be the most important protection device, companies value legal or other "formal" protection methods in that patents signal competencies, credibility and viability to other firms and provide a bargaining power when negotiating with larger firms:

"Patenting is absolutely necessary in our field. Without patents, the firm is not taken seriously by customers or other firms in the field. It is a value in itself, upon which the whole existence of the firm is based. We had a competitor firm in France that was founded a year before us. They went public and expanded by almost a thousand employees in two years, but they didn't have a single patent of their own. Then the tough times came, and they only have 45 employees left now. If you do not have your own patented technology, you will not have any value in the long run either." (Director of fast-growth SME targeting international markets)

"Whatever it is we invent, we must always file a patent application. It is our patents that place us in a totally different position from the customer firm's viewpoint, if we can demonstrate that we have even some kind of patents. Without it, the big firms in our field would simply copy our concept and make the products themselves." (Director of SME integrating new technology in traditional branch)

An implicit indication from the above is that, especially in high-tech fields, small and medium-sized firms consider formal protection of intellectual property essential, although this varies by sector (cf. Rappert et al. 1999). The primary reason for the lack of importance given to IPRs derives from the lack of necessary resources to acquire and enforce IPRs. This is the reason why SMEs may be unwilling to apply for international patents, and be more likely to use secrecy to protect their invention, as long as possible. In practice, it is impossible for small firms to defend their own patents against large multinational firms.

With respect to sharing intellectual property rights with universities, all SME managing directors preferred informal negotiation concerning the ownership of intellectual property to formal procedures. The SMEs' desire for informality with university contacts was noted in the discussions regarding the negotiation over intellectual property rights:

"We always clearly define the ownership of the IP in our research contracts. It seems that this is becoming more complicated, because universities have their own interests. I do not know whether the situation will become more difficult in practice. Nevertheless, we will be obliged to pay royalties to universities, based on some legislation. But it will not be a problem, because if an innovation yields profit, it is only fair that all those who have been involved get their share. This may be more problematic for new firms than for established ones. Luckily we have freedom of contract in Finland, i.e. it [the payment of royalties to university partners] depends on the contracts that have been made." (Director of fast-growing SME targeting international markets)

The suggestion that IPRs can create tensions by shifting universities from being relatively open suppliers of ideas to industry (Rappert & Webster 1997) does not get support from this study. Overall, there was little indication that the linkages with universities were negatively affected by the growing interest of universities to benefit from commercialisation. The results show that 61% of those SMEs that had collaborated with universities or other public research organisations had utilised in one way or another the technology developed with a university or other public research organisation. Also, less than one out of ten said that they had faced problems in the collaboration, due to the utilisation of academic

results or the protection of the invention developed together with a university or other public research organisation. Hence, there is still a weak perception of the change that is taking place inside the universities among those firms with significant contacts. Typically, this is associated with the growing contractual and commercial orientation of universities.

"It [the IPR issue] has not been an obstacle to collaboration for us. The university partner filed a patent application for an invention they had made themselves. It is ok for us that they patent. A significant part of the work is created in a dialogue: based on our specification, draft or idea, they build a prototype for us. If someone wants to patent a specific feature, which is an essential part of the whole concept, a conflict would emerge immediately. They themselves realise that it would not be wise. The collaboration would end at once." (Director of SME integrating new technology in a traditional branch)

Potential tensions between universities and firms seem to derive from an overvaluation of the IPRs by the universities. The more university partners become aware of the potential economic benefits that may accrue from collaboration, the more conflicts of interest are likely to arise with respect to sharing the ownership rights.

Although disputes between firms and universities appeared rare, one director from a knowledge-intensive start-up firm criticised university researchers working in technical university for overpricing their research results, which is likely to have a detrimental effect on collaborative relationships. Overpricing contributes to decreasing firms' interest in co-operating with universities. The firm director expressed the desire for clearer rules and the independent assessment of the pricing of inventions. Furthermore, co-operation can also be hampered by the researchers desire to participate in business management, even if they do not have competence in that area. The firm in question was established on the basis of an invention made by university researchers who, during the early stages of the establishment, had been both firm shareholders and worked in the firm's management. As the firm's financial situation deteriorated and the firm neared bankruptcy, a new professional director was hired for the firm. The present director estimates that the firm's weak financial performance was the result of that ownership base and of the problems related to the inventors' unskilled management style. Previously, the firm had mainly focused on the technical development of invention, neglecting strategic planning and marketing.

In another controversial situation, the research organisation had first sold the rights of the invention to a technology transfer firm, which in turn sold the invention to a firm. Later on, as the firm began to develop the invention for the market, the researchers had asked the firm to pay separate compensation from the sale profits. Indeed, the entrepreneur in question expressed dissatisfaction with the method used to commercialise the inventions by public actors.

These two examples show that compensation practices concerning inventions emerging from universities and other public research organisations are still very unclear and have an ad hoc basis. From the viewpoint of SMEs, the formalisation of university IP is not a solution of the governance of IPR. Given the general value placed on IPR, the firms' emphasis towards strengthening the formalisation of relation within universities is hardly surprising. A common set of guidelines, including clearer rules for conflicts of interest, contractual arrangements addressing the conditions for exclusive licensing are called for. Such guidelines would benefit both potential industry and university partners, offering a base for negotiating the contract and for ensuring that the shared information remains between the contracting parties.

The formalisation of IPRs may have a negative impact on the networking of universities and firms. It has been argued that many large firms resist university control over intellectual property due to the fact that they aim at controlling the rights for themselves (e.g. Webster & Packer 1996). In the case of the small and medium-sized firms interviewed here, however, the opposition to university control stems from the view that the negotiations surrounding the property rights are a process of mutual give and take. In this respect, flexibility to negotiate over the IPRs is a vital prerequisite to succeed in public-private research collaborations. It is obvious that the formalisation of relations may particularly impede the position of start-up firms, which seldom have sufficient capital to buy out the IPRs. This suggests that the Finnish government's interest in promoting a greater utilisation of academic research is likely to meet its limits in the areas of most use to firms.

6.6 Significance of public support on collaboration

During the last two decades, Finland and other European countries have been proactive in promoting university-industry interaction. To analyse the effect of public funding on the cross-sector collaborations, it was important to examine the additionality of EU funding. In the survey, the respondent was asked to indicate whether R&D would have been carried out anyway without the EU funding. Furthermore, we asked whether the EU funding enabled the project to be conducted faster, or on a larger scale or differently, and whether the project would have been carried out at all without it. To analyse whether there is a relationship between the degree to which a firm might exploit public research and its size (Link & Rees 1990; Acs et al. 1994), the responses were grouped into two groups: large firms and small and medium sized companies.

As shown in Figure 18, Finnish firms' perceptions of the significance of EU funding did not differ much between companies collaborating with universities and the ones who did not. Nevertheless, the significance of receiving EU funding was somewhat higher among small and medium-sized enterprises (SMEs) collaborating with universities than among large companies with the same status. Again, the analysis of the strategic value of the EU project and collaborating with a university shows that no statistically significant differences between collaborating and non-collaborating firms were found (Figure 19). Nevertheless, the EU project had a high strategic importance particularly for those SMEs collaborating with universities. Conversely, for large firms in partnership with universities, the project was of potential future importance. In the context of EU FPs, SMEs pursue their central interests through the EU project while large firms carry out projects, with a potential future importance with longer-term focus.

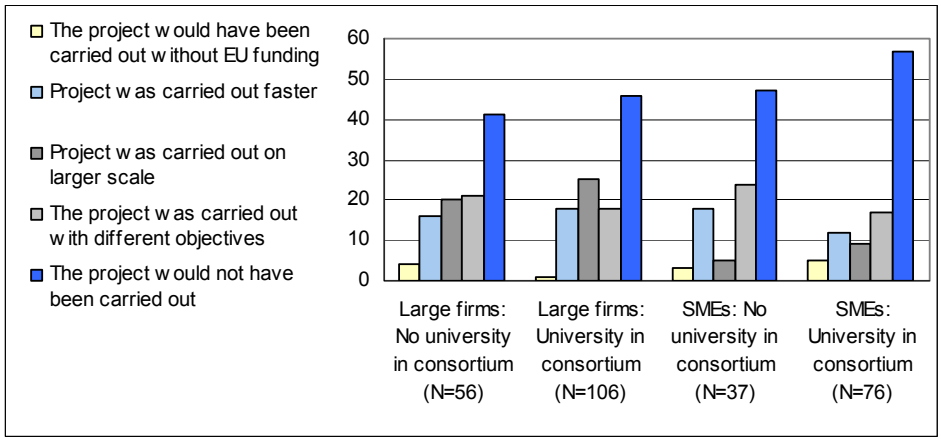

Figure 18. Additionality of EU funding for Finnish firms by type of consortium in FP4. Share of respondents who agreed with the statement (percentages). Survey 1999.

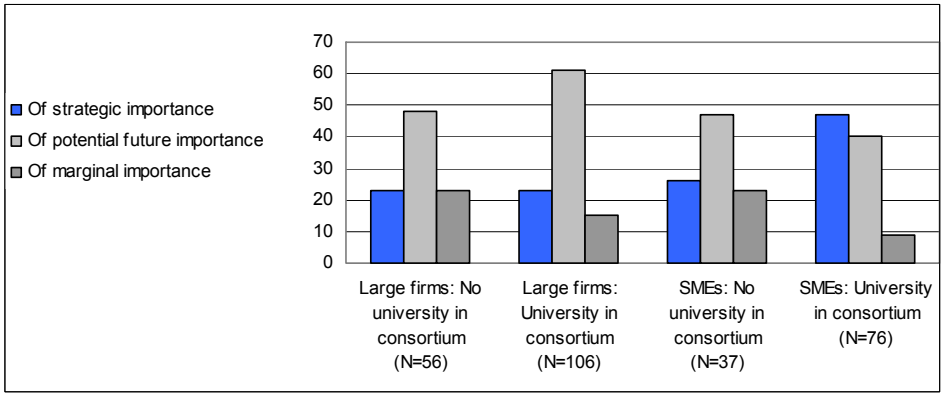

Figure 19. Strategic importance of EU projects for firms by type of consortium in FP4. Share of respondents who agreed with the statement (percentages). Survey 1999.

Overall, the results confirm previous evidence highlighting how firms establish a variety of relationships with universities in order to pursue different objectives. The findings of the present study are also consistent with those of the corporate strategy literature, i.e. that large firms seldom outsource technology in their core competence area (Santoro et al. 2002).

Unlike their larger counterparts, small firms are usually more concerned with survival and, to this end they establish university-industry relationships. They offer more immediate solutions to critical issues affecting their central business areas and core technologies (Steele 1989; Santoro et al. 2002; Corsten 1987; Foster 1986). Small firms are often bound by having limited time and by suffering from financial constraints when pursuing technological innovations outside their core domain. Furthermore, they often have a limited pool of in-house talent (Acs & Audretsch 1990; Santoro & Chakrabarti 2002). For many small firms leveraging core competencies in areas central to their business this is a critical concern.

All in all, the findings in this study depict the universities' minor direct role in commercialising research results. On a general level it can be stated that the collaboration has had no direct impact on achieving business-related outcomes and commercialisation. However, the above results point to the vital importance of public support in enhancing knowledge flows between SMEs and universities. Inconsistent with prior findings, large firms were not more successful in generating direct and indirect results from university collaboration than SMEs. On the contrary, the surveyed Finnish SMEs benefited from the EU projects more often than the large firms when universities were engaged in the project.

7. Characteristics and impacts of entrepreneurial role of universities

The scientific system is experiencing significant organisational, cultural and institutional changes (Senker 2001; Etzkowitz et al. 2000; Nieminen 2005, Slaughter & Leslie 1997). Universities are expected to contribute to economic growth and societal welfare through being actively engaged in entrepreneurial activities. Furthermore, it has been suggested that the intellectual boundaries between academia and industry are breaking down. The direct and indirect consequences of this entrepreneurial role are still far from known. In fact a major open question is if and how universities are able to deal with the changes in the social context of the academic world. These changes relate to the imperatives of scientific research, as well as the involvement of industry and other external actors.

This chapter discusses the major findings drawn from literature and empirical data. It is clear that any single field of research alone has not succeeded in explaining the ongoing changes in the university system. Therefore this study has adopted an integrating strategy by focusing on academic, economic and societal rationales for science. Through these three rationales it is possible to understand both internal and external factors affecting the university and its entrepreneurial role. The study has also further developed Stokes' Pasteur Quadrant by adding the element of cultural dimension of university research. According to Stokes' model, the key to understanding the complex nature of the entrepreneurial role of universities is to look at how the academic and economic goals are intertwined. A quadrant model developed in this study is aimed to provide an analytical framework for understanding the multiple university roles and responses towards academic, economic, societal needs. This conceptual model can be regarded as an ideal model that involves both cognitive and cultural dimensions of university research behaviour.

The quadrant model of university approaches towards market has many advantages as an analytical tool. It helps to identify the various roles of universities in knowledge production. In the four-quadrant models, the research traditions, beliefs, different organisational strategies, as well as internal and external knowledge demands are considered. Furthermore, it goes beyond linear

thinking by taking into account the cognitive dimension of integrating academic and utilitarian demands. The proposed model is a useful tool when addressing the challenges and tensions that the university is facing when and if increasingly engaged in entrepreneurial activities. It also provides a penetrating tool with which to examine the relevance of policy interventions, opening the way for the redefinition of policy actions and further research. The extent to which this model corresponds to the conceptions of university scientists is tested empirically. To this end, the present study illustrates the emergence of the entrepreneurial university in Finland in the late 1990s and the early 2000s by focusing on the cultural, institutional and organisational factors and mechanisms affecting university-industry interaction.

7.1 Extending university role

The quadrant model of university responses to market implies multiple roles and functions for universities, in both the R&D system and in society. It highlights pluralism and the extension of the university role beyond research and education, thus encompassing dissemination and utilisation of research results to the benefit of both economy and society. The empirical analysis shows that Finnish university researchers have adopted different approaches and behavioural patterns to respond to the entrepreneurial demand. Rather than presenting a homogeneous behavioural response, some researchers see the commercialisation function as threatening. Concerns regarding the decreased openness and autonomy in conducting research, as expressed by some academics in the study, reflect the Mertonian approach to the role of universities. However, some researchers regard the entrepreneurial role as beneficial to their research. These "entrepreneurial-oriented" or "societally-oriented" academics simultaneously pursue academic and utilitarian goals by applying theoretical knowledge in a practical context. In addition to contributing to the advancement of science, they see the interaction with industry, commercial activity and the solution of societal problems as a legitimate role for universities. They reflect the economic and societal rationale for enhancing unversities' engagement in the utilisation of research. This conception of the scientific work also contradicts the old concept of an impartial "ivory-tower" scientist.

The entrepreneurial approach also represents the increasing competitive financial environment. Through entrepreneurial activity, academics make their research more visible and attractive to public and private financiers. Economic and professional advantages must, however, exist if academics are to engage in entrepreneurial activities. If the search for external funding only means an increase in the organisation's funds, then the researcher will have little incentive to make any effort in this direction. More importantly, the principal objective of the university's actors involved in research is the continuity of their activities: the reproductivity and educating new researcher generation.

In general, the positive and negative attitudes observed among university researchers towards entrepreneurial activities reflect the cognitive and cultural changes taking place in the conduct of academic research. The intertwined relationship between basic and applied research contradicts the linear thinking of research, development and innovation. The practical level of research and development has also seen a gradual move towards the interactive model, where fundamental understandings and practical use are simultaneously pursued by academics. Accordingly, the scientific problem solving and theoretical work can also take place in an application-oriented context. The findings also indicate differences in academic value basis and variety in the views regarding what academics themselves consider appropriate behaviour within the academic community.

Problems and conflicts of interest arising from an entrepreneurial role

Research findings in this study support the view that scientific and utilitarian (commercial or societal) goals can be intertwined, although potential tensions and conflicts of interest between academics and entrepreneurs may arise. These tensions are not, however, regarded as an actual threat to the universities' autonomy. Conflicts of interest between universities and private sector partners emerge rather from the confrontation of research cultures and normative structure, than because of essential divergences between basic and applied research. Indeed, utilising research results in universities is a question of reconciling cognitive differences and similarities, rights and opportunities, as well as balancing different demands and responsibilities. Obviously, the "entrepreneurial norm" may not be applicable to all fields of science, nor do all

academics and university institutions have the relevant competencies or the willingness to adopt an entrepreneurial role.

The analysis of the Finnish participation in the EU-funded projects offers conflicting information regarding the impact of the university-industry interaction with respect to the research quality. From the firms' viewpoint, collaborating with universities improves the research quality of the project. Conversely, from the university perspective, research quality may be lower than in the cases where no firms are involved. Nevertheless, collaborating with firms has not hindered academics from publishing scientific articles.

The quadrant model implies an extension of quality control mechanisms, in order to include new criteria and constituencies, without making quality judgements on basic and applied research. Purely scientific criteria are not sufficient to describe and evaluate the quality of academic research. New criteria include, among others, relevance to users and the societal or commercial utility of research. Consequently, academics seek to deal with scientific excellence, and they also increasingly deal with issues such as practical utility and credibility. Academics seek new ways to legitimise their curiosity-oriented research projects through a bargaining process with financiers and contractors. The bargaining process is also important for succeeding in collaborations with firms. Indeed, having a mutual understanding of the goals of the project and creating a win-win situation among the research partners involved are factors that enhance the potential success of the collaborative project. Some Finnish academics criticise the fact that, sometimes, firms do not bring their best repository of knowledge into the collaboration. Up till now, the concrete terms, the practical and close collaboration between university and firm partners has been found lacking. The spatial closeness of collaboration between universities and firms is an issue that has not been tackled in depth in the research literature. However, there are reasons to believe that the long-term and close collaborative relationship between universities and firms would enable a successful commercialisation of academic research. Evidently, further analysis is needed to establish a better understanding of the long-term impacts of the university-industry collaborations on both production of new knowledge and academic publishing patterns.

A closer relationship between university and industry has brought both beneficial and distortive elements into academic research. When academic

research becomes a part of a larger cycle of action, more and more importance is attached to academics' entrepreneurial and managerial skills. When carrying out the entrepreneurial activities with industrial partners, universities have adopted some characteristics of the business world. Consequently, some tasks and roles of universities and industry have become more alike. Nevertheless, no strong evidence is found that university academics are pursuing purely economic revenues when they engage in commercial activity (cf. Etzkowitz 2003; see also Tuunainen 2004, p. 58).

Blurring the boundaries of public research organisations

Another important finding of this study is that the contributions of universities and governmental research institutes in the EU-funded projects were remarkably similar, suggesting an overlapping and blurring of research roles in these institutions. It seems that some Finnish universities increasingly carry out applied research while, at the same time, governmental research institutes direct their activities toward mission-oriented strategic research, close to basic research. The old division of labour between fundamental and applied or problem-oriented research is disappearing, and with it, the functional distinctions between universities and public labs.

The division of labour between universities and public research institutions (as well as polytechnics) in knowledge production has not been greatly discussed in Finland. Given the evident blurring of boundaries among these institutions, it can be asked whether it is economically viable to maintain two separate public organisation types with overlapping functions. These overlapping research roles may add negative competition, thus hindering the free flow of knowledge and co-operation between these organisations. The increasing overlapping functions in the public research organisations may also signal a temporary adjustment of task priorities amongst universities, in order to cope with funding fluctuations and the increasing competitive environment in which they operate.

7.2 Organisational diversity and management as critical assets

A central hypothesis, at the institutional level, is that the entrepreneurial role of universities is significantly affected by the organisational and the changing financial environment. Given a certain discipline, factors such as size, financial constraints, educational responsibilities, lack of appreciation of industrial R&D and lack of strategic management are important to explain the universities' diversified entrepreneurial performance.

The quadrant model also emphasises the need for the development of new technologies and multi- and interdisciplinary research. A stronger market orientation and entrepreneurial capabilities are more obvious in large departments and interdisciplinary research centres, rather than in smaller and unidisciplinary departments and faculties. In contrast, institutions with little co-operation between research groups and many teaching responsibilities perform far worse when applying for external research financing. They are also less often involved in entrepreneurial activities. Although interdisciplinarity and networking, as new configurations for academic research (Gibbons et al. 1994) are much discussed and elaborated upon, there are only a few examples of the content and consequences of interdisciplinary research (see also Bruun & Toppinen 2004). Evidently there is a need for a more concrete theoretical approach to identifying both the impact of interdisciplinarity and networking, as well the phases of the evaluation exercise focusing on the interdisciplinarity of research.

A set of managerial mechanisms seems to reinforce entrepreneurial behaviours. University institutions that have adopted the idea of carrying out the work of academic researchers in closer contact with market-oriented industrial R&D projects and promoted a business-like management culture, have an advantage in the research market. The analysis also highlights the importance of inspired and goal-oriented leadership in facilitating the institute's good working climate and the institute's involvement in commercial activities. A leader's critical attitude towards commercialisation can, on the other hand, form an obstacle to the researchers' involvement in the commercial utilisation of research. In terms of commercialisation, the institute's leadership culture, the internal distribution of workload and responsibilities may hinder or enhance the commercialisation of

academic research. Hence, the institute's ability to set goals, obtain funding in an organised manner, and gather expert knowledge from different fields are important prerequisites for enabling the university to meet the market demand.

When considering the commercial role and capabilities of universities, the way in which their activities are managed is of high importance, but, so far, the topic has been relatively little discussed. A big challenge here lies in the universities' social and organisational capabilities to learn how to co-create value with firms, while simultaneously maintaining academic and economic objectives. Another interesting issue is how universities are building intellectual capital and adopting the "knowledge sharing culture", which is often required in a multi- and interdisciplinary and application-oriented research context.

Impacts of competitive and entrepreneurial approaches

All the ongoing changes have both direct and indirect consequences on the structures and research culture of universities. The interaction between universities and private firms has given rise to various institutional configurations, thus underpinning the different organisational forms and working communities in academia. These institutional configurations represent different societal models of organising academic activities, teaching, research, and the dissemination and utilisation of research. Management, networking and achieving a critical mass are central to both the market competitiveness and vulnerability of the university itself.

The entrepreneurial role has changed the administrative strategies of universities. These strategies increasingly aim to integrate academic, commercial, and bureaucratic cultures, decreasing the distance between universities, business and industry, and between universities and society. To some extent, the competitiveness approach to funding and market demand have increased the polarisation of the Finnish university system, with a group of dynamic research-oriented institutions and a group of mainly teaching-oriented institutions. The disciplines and the institutes that are close to the market, having an entrepreneurial inclination, attract comparatively more financial resources. It is still uncertain to what extent they also attract the most talented researchers and students, because of the better career prospects (see also Slaughter & Leslie 1997). Institutes that are far from the market and those with a greater emphasis

on teaching will not have the same potential to obtain external research funding and they see the number of students diminishing. This development may have some counterproductive consequences for the university system. In the worst case scenario, competitiveness may create disincentives for researchers to engage in projects where they cannot obtain quantifiable outputs to be used for evaluation purposes. Academics may also become reluctant to contribute to educational and training duties, and less motivated to carry out research projects with long-term horizons. There may be certain long-term negative side effects too. If universities begin to seek ways to profit from their inventions, this is likely to threaten the public character and objectivity of their work.

However, the competitive approach and entrepreneurial role may have advantages as well. As a result of the competition that takes place at various research levels, the Finnish university system has become more responsive to economic needs. The benefits of the entrepreneurial tasks include increased prestige and visibility of university research in society, and higher returns for the university, departments and scientists. Concentration of research funding may be beneficial for achieving a critical mass for research and scientific advancement. Risk taking and the recruitment of high-level researchers is only possible in fairly large research units, where funding is guaranteed for years ahead. Granting funds to ever larger entities may increase the internal autonomy of research groups. In this way, the groups themselves can decide how to use the funds they have received. In the present increasingly competitive environment, universities benefit from their external relationships in various ways. Through firm collaboration, researchers can learn to recognise the value of the research they generate, have access to and use data. Furthermore, collaboration with firms may bring new ideas and perspectives for starting new research paths.

All in all, the marketlike behaviour has become a part of universities and may have consequences for the visions and roles of universities in the knowledge-based society. As the research interests of the departments are, after all, bound to their traditions, there may be tensions between old and new theoretical orientations (see also Häyrinen-Alestalo & Peltola 2004). Solving these problems creatively represents the principal challenge for those universities that aim to benefit from the opportunities of the market without losing their integrity in the process. If the operating principles of the entrepreneurial activities are not clear and transparent, they may weaken the social integrity of the university. As

the academic and entrepreneurial realms become blurred, maintaining success may increasingly depend on the ability to achieve both regimes simultaneously. Therefore, making commercial activities more transparent, both inside and outside the universities, as well as balancing the academic, economic and societal activities, are important challenges for universities.

7.3 The universities' role in the development and commercialisation of technology

Despite the growing awareness and emphasis on utilitarian demand among university scientists, universities have not played a significant role in the commercial utilisation of research results or in translating their knowledge into intellectual property that can become a commodity. In the light of industry responses, primary interests in universities seem to be related to the supply of an educated workforce and assisting industry in solving fundamental research problems that industry itself has neither the competence nor the resources to deal with. The analysis of the interfaces between university and firms points to the conclusion that partnership with universities is of high importance for Finnish industry. Co-operation with universities in the EU projects has coincided with an increase in new knowledge and competences, as well as added visibility and prestige in the international arenas. The collaboration has, however, had no direct impact on achieving business-related outcomes and commercialisation. Therefore, partnerships with universities in the EU projects need be thought of as an "admission ticket" to research and technology networks, rather than a platform that produces direct commercial benefits.

The EU funds and university collaboration, in particular, are of higher additionality to SMEs than to larger firms. The majority of research projects of SMEs with university partners would not be carried out at all without public funding. EU funds had enabled small firms to overcome some resource constraints to their involvement in large-scale formal links with public research organisations. For SMEs, collaborating with universities and public research organisations is valuable in order to develop strategically important technologies in their core areas, while for large firms the collaboration with universities provides opportunities to establish technological capability in new areas. The implications of these findings for policy design are clear: encouraging SMEs to

join public research programmes is crucial to ensure their technological expertise and competitiveness. This approach also anticipates the net social benefits that can be generated in this way. The more the Finnish SMEs are involved in EU projects and networks, the better the opportunities for the Finnish SMEs to take advantage of the technologies developed by the European firms and public research organisations. Nevertheless, to better meet the innovation needs of the SMEs, further public initiatives to support the SMEs' R&D capabilities to take advantage of the R&D is needed.

Trust, mutual respect and understanding seem to be of crucial importance to small and medium-sized enterprises when they collaborate with universities. This highlights the importance of informal linkages as a channel for transferring knowledge and know-how from universities to SMEs. In the discussion about reassigning intellectual property rights to academic institutions, it emerges that over-formalising these relationships may distort interactions between university and industry. Despite the above concerns, formalisation may provide a set of benefits such as greater legal certainty for the parties involved, and lowering the transaction costs of each partner's bargaining positions. As the interviewed SME directors stressed, the arrangements with universities should remain informal and negotiable, although general rules are needed for the pricing procedure. This means that universities should strive to set some guidelines that are simple and uniform but, at the same time, these need to be flexible enough.

The universities' growing interest in gathering commercial gains has not decreased the interest of small and medium-sized enterprises to collaborate with universities. Nevertheless, evident tensions between universities and firms derive from the overvaluation of IPRs and from the unrealistic expectations of economic revenues existing among university researchers. Likewise, cultural differences in communication and working methods seem to represent a real barrier for succeeding in university-industry collaboration. Successful collaboration between university and industrial partners requires closer collaborative arrangements, commercial skills and a better understanding and awareness of the commercialisation strategies of the firms.

From the firms' viewpoint, by and large, universities are seen as potential sources of new knowledge and expertise. Firms very rarely exploit the IP generated by universities. The continuing knowledge flow, new ideas and skilled

staff provided by the public research sector seem to be much more important for the firms than patents and other formal IPs. These findings offer considerable support for the conception of an interactive innovation process, where public research will sometimes lead technological development, but, more typically, downstream research and development. University research has also provided impetus and guidance for what industrial R&D labs should do (Gibbons & Johnston 1974; Kline & Rosenberg 1986; von Hippel 1988; Rosenberg & Nelson 1994). New scientific knowledge, which is primarily achieved through public and personal channels, is of substantial importance to industry. Hence, no significant changes in the role of the universities have occurred in this respect.

When innovation relies on a technology base with a high science content it is important that all parties have access to the new knowledge and to the technology developed by universities and other public research organisations. Public support for innovation needs to better communicate the prevalence of innovations' market failure (see Martin & Scott 2000; Pavitt 1984; Palmberg 2004). The extent to which public support should be directed to each sector and to the different sized firms varies. In this regard, a single supporting framework for all firms may not be sufficient. SMEs may need subsidies to acquire new capabilities and linkages, support for training and support to take advantage of foreign technologies. The division of labour and conditions in which all parts of the system are networking and can preserve their own specialised to the innovation activities are important to the complementarity of the innovative activity of private and public actors.

7.4 Policies fostering the entrepreneurial university

Since the mid 1980s until the present day, the economic rationale of science has had an important role within the Finnish science and technology. The prevalence of an economic approach is shown by the increased cooperation between industry and universities and the significant increase of Tekes' funding. The development of closer linkage between science and economy is also accelerated by the new policy schemes and seed finance intended to encourage the development of promising university IP and spinout activity. In addition, more funds are awarded on a competitive basis and through intermediate public

funding bodies. Universities are thus expected to put more emphasis on business partnerships and commercialisation of their research.

Counter-balance to such developments, the support of internationally high quality scientific research in universities has been especially taken care of by the increased funding granted by the Academy of Finland. The funding decisions of the Academy have largely been made on the basis of scientific quality and qualifications. Establishing graduate schools and centres of excellence have been important efforts to upgrade the academic tradition of Finnish science and technology.

In fact, since the mid-1990s, the debate on the universities' "third function" has been the focal policy focus. In the debate, the commercial utilisation of research results has been prevalent. The concrete implication of university engagement in entrepreneurial activities is the reform of the legal framework for university inventions. The reform will oblige universities to enhance the commercialisation of the results emerging from their research. With growing importance put by universities on the commercialisation of research, academics may be confronted with the new research challenges posed by the economic and societal development. In this respect, academics are faced with the suitability of applications and technologies to the users. A crucial question is for whom these technologies are developed and for what purposes? So far the in the debate on the universities' "third function", expert and educational duties as forms of dissemination of research into society have gained little attention. Also, the government's interest to direct further resources for these kinds of activities is minor.

Needs for promoting interdisciplinarity and use-inspired basic research

In Finland, the present public research system has been criticised because it barely meets the innovation needs of the new technologies (see e.g. Georgiou et al. 2002; Gibbons et al. 2004). Such a concern has called for greater interaction amongst the funding institutions, such as the Academy of Finland and the National Technology Agency, Tekes (Gibbons et al. 2004). In Kuhnian terms, when promoting scientific advancement, more space needs to be given to multiparadigmatic sciences, which trigger the development of new paradigms.

The Finnish public financing system for research and development has remained almost unchanged during the past 20 years. The current public funding system for research and development in Finland follows the linear innovation model, created after the Second World War. In this system, the Academy of Finland is responsible for promoting high-level basic research, while the National Technology Agency of Finland (Tekes) supports applied research and development. In this respect, it is justified to ask how relevant and effective the present funding system is in promoting "multi- and interdisciplinary" or "use-inspired" basic research as the quadrant model proposes.

Although Finnish science and technology policy has been very successful over the past decades – as numerous international rankings show – the present developments in research and innovation challenge the financing system. The process of bringing together two quite diverse kinds of judgements shapes the agendas of use-inspired basic research, i.e. scientific research and societal needs. Supporting interdisciplinary research requires expertise from both sides. Within the innovation studies tradition, networks, interdisciplinary research, and the links between private and public actors have been identified as key factors for the exchange and distribution of knowledge, as a means to support innovation. When adapting research funding to match the emerging characteristics of the innovation systems, the interaction between funding organisations might benefit from a horizontal-governance innovation policy. A better understanding of the integration needs and the impact of co-ordinated research programmes is needed, so that network and university-industry interventions can take new and more sophisticated forms.

If academic institutions are required to take on a more direct economic and societal role, should the policy efforts be targeted at the demand side instead of supply?

Despite pouring generous resources into research and development, Finland performs poorly in commercialising academic research. Various policy schemes and institutional frameworks for commercialisation have been established, but there still are severe bottlenecks and incentive traps that hinder the commercialisation of science-based inventions. Personal incentives are also lacking. The growing importance of knowledge demand across industry sectors represents one important, yet often ignored, aspect of this debate. For instance,

the capacity of small and medium-sized firms to absorb and utilise the knowledge generated by universities needs further attention.

When policy goals are top-down, the desire of universities to implement them may vary, especially since universities possess different capabilities to engage in this activity or because they pursue conflicting incentives. The system does not work if incentives are not aligned. The functional structure is not achieved merely by increasing public funding, promoting interaction between academia and industry. Nor does automatically handing the property rights to the inventor create the best incentives for commercialisation. These interactions should not be policy-driven. The outcome would be better if the interest for commercialisation would arise out of the desire and need for exchange. Attempts to over-formalise university-industry linkages might have a pernicious impact on the informal patterns of social and economic interaction. The utilisation of academic research calls for flexibility in policy, so that it can better account for the divergent demands.

Promoting the absorptive capacity of different types and sizes of firms seems to be an area where much could be done to promote innovation. Promoting development and innovation activities in public services (e.g. the health and social service sector) seems another issue that needs further attention. In general, it seems, however, that market mechanisms between universities and firms work better today than they did a few decades ago. Nevertheless, greater networking between the two sectors may obscure the decision making regarding the policy intervention for research.

Restricted mobility of human capital still remains a significant obstacle to knowledge transfer between academia and industry. At the policy level, a lot of effort has been put into establishing new intermediary organisations, such as technology transfer and patent support offices, while little attention has been given to removing the barriers of the mobility existing between the two parties. The temporary recruitment of researchers to firms, or their use as experts, is a rather little used route to transfer the knowledge and know-how produced by universities to society. Granting sabbaticals and increasing personnel exchanges between firms and universities could be one way of strengthening the transfer of information to society and economy. Publicly-funded joint research projects could also be more supportive of personnel exchanges between research

organisations and the private sector. Pension regulations limit mobility between the public and private sectors. Employee exchanges based on fixed-term contracts could help prevent the legal disqualification and conflicts of interest that occur when the commercialisation of research results in university researchers taking on the dual role of a university teacher/researcher and entrepreneur. In order to bridge the cultural gap in knowledge transfer between the two sectors, attention needs to be paid to promoting mechanisms that would allow university researchers to participate in developing the product idea, as well as its follow-up.

Promoting academic entrepreneurship

Finnish academics' interest in entrepreneurship is at a low level, compared to many other countries. The cautious nature of Finns to enter entrepreneurship and the desire for security, as well as the possible lack of entrepreneurial competence, have been blamed for this. Obsviously, academic entrepreneurship may take various forms and behaviours which modify pattern of research, accumulate resources, build new organisational structures and networks. Above all, it requires distinctive competencies such as technical and managerial capabilities and skills to find a balance with profit seeking activities and knowledge creation. This study indicates that many Finnish academics are willing to pursue entrepreneurial activities, but they cannot find the appropriate channels to become more engaged in these activities.

Based on many evaluation studies, a lack of funding or expert services supporting academic entrepreneurship cannot be considered as barriers hindering academic entrepreneurship. Conversely, the problem would seem to be the inconsistency of the public and private services supporting the establishment of innovative start-up firms. For example, the development solutions of firm incubators and firm development activity have more or less remained without co-ordination at the university, municipal and national level. This has resulted in a large number of financiers and service providers who are providing services to start-up firms. However, it remains difficult for academics to identify the appropriate actors for the counselling they need. The ideal case scenario would be that new entrepreneurs would obtain services from the same information source at both their start-up and critical initial stage. On the general level, technology development and innovative activities require a university

organisation which allows for easy and direct communication among scientists and entrepreneurs of the firms. Such an academic organisation should make it easy for the persons involved change their roles and work in organisational units suitable for the task at hand. By creating a career structure which encourages the emergence of new role combining teaching with use-inspired research work as well as creating mobility of personnel between universities and industry are likely to facilitate commercial utilisation of academic research.

The role of EU framework programmes in promoting commercialisation

A growing share of the income of universities in Finland is generated through collaborative research projects and contracts funded by the national public authorities and the EU. Participation in EU R&D programmes has become an issue of great importance in many fields. The EU framework programmes for research and development – as an example of public intervention in science and technology – have played an important role in bringing producers and users of knowledge together, and in influencing the functions and conditions of universities as knowledge producers. The research collaboration enabled by these programmes has opened the way for a new research framework that entails a better understanding of how to combine academic and utilitarian goals. Through these collaborative projects and their learning processes with firms, universities have learned to understand the potential commercial value of their research, as well as the specific needs of firms and other end-users. Universities have also become better aware of the innovation process itself and its mechanisms. However, there still remains a gap between the generation of new knowledge and know-how and the diffusion of commercialisable innovations. The outcomes of EU projects have not materialised as immediately commercialised products or processes, as was expected.

Future appeal of universities

Finnish universities possess considerable cognitive and societal authority within the Finnish society. Over the past two decades, they have been capable of adapting to the changes happening in their operating environment by networking and focusing on the interaction with various societal actors and top experts, both nationally and internationally. Nevertheless, universities have compromised some of the standards of their scientific behaviour, which have long been

considered as one of their important strengths. Increased secrecy in research and conflicts of interests with corporate sponsors are concerns that are taken seriously by academics.

A burning issue in today's debate is the sustainability of the research infrastructure and how to secure a necessary level of basic research. This is essential since firms rely on collaborations to access more explorative types of research. Such a phenomenon entails pursuing an optimal balance between basic and competitive funding for research and development, from the viewpoint of efficiency and quality of academic research.

The prosperity of universities in the future will depend upon how well universities are able to attract talented and skilled professionals. The great increase in the number of students has meant significant additional responsibilities and extra work for professors and teachers, which, in turn, has narrowed their opportunities to conduct longer term, scientifically inspiring research. The current funding system for university R&D is also criticised for the excessive administrative burden involved. In particular, the time and effort invested in applying for external resources of research are considerable. The salary of university teachers in comparison to their workload is not very competitive either. These factors may play a decisive role in decreasing or increasing the attractiveness of university careers.

Transparency in the decision-making processes, especially concerning the commercial role, is vital for the future development of universities. Prioritising the allocation and use of available resources is needed, so that universities can properly handle their basic tasks – high-level research and the highest education that is based upon it. As this study has shown, many academics seek ways to apply their knowledge for commercial or societal purposes. University involvement in the commercial research arena cannot be avoided – some fields of science are already there. The commercialisation of research results is not an absolute value; it can complement the universities' other functions. The commercial arena provides a new configuration for solving problems that may be of both practical and scientific interest and benefit. The entrepreneurial norm is emerging in the university, however not necessarily at the expense of scientific endeavour, but rather to its advantage.

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Appendix 1: The research data used in the study

Data	Focus of data	Number of respondents	Area of interest
1) Re-analysis of the survey on Finnish participation in the Fourth Framework Programme conducted by Terttu Luukkonen and Sasu Hälikkä in 1999–2000.	University and firm experiences in the Fourth Framework Programme (running in 1994–98)	University respondents: N=167 (67%). Large firm respondents N=146 (72%). SME respondents N=98 (68%).	Significance of university collaboration; university contribution to the technological development and innovation
2) Re-analysis of the survey on experiences of Finnish university participants in the EU Fourth Framework Programme for R&D conducted by Pirjo Kutinlahti in 1999.	University experiences in the EU Fourth Framework (running in 1994–98)	University respondents: EU participants: N=103 (54%) Non-participants N=86 (46%)	Reasons and motivations influencing the university-industry collaboration and problems, benefits and other outcomes of collaboration.
3) Re-analysis of the survey on Finnish participation in the Fifth Framework Programme conducted by Marjo Uotila, Pirjo Kutinlahti, Soile Kuitunen and Torsti Loikkanen in 2003.	University and firm experiences in the EU Fifth Framework Programme (running in 1998–2002)	Large firm respondents N=55 Small and medium-sized enterprise respondents N=24	Significance of university collaboration; university contribution to the technological development and innovation.
4) Re-analysis of the survey on the views of Finnish SMEs on innovation environment conducted by Pirjo Kutinlahti, Juha Oksanen, Torsti Loikkanen, Jukka Hyvönen and Bernd Ebersberger in 2002.	Perspectives of small and medium-sized enterprises (SMEs) on university partnership (the initial project explored the Finnish innovation environment)	Small and medium-sized enterprise respondents N=98	Costs and benefits of university partnership
5) Interviews with university staff conducted by Pirjo Kutinlahti in 1999 and 2000.	Structural, institutional and cultural developments in Finnish universities in 1990s	Number of interviewees 78	Factors influencing the adoption of market-like behaviour and entrepreneurial role
6) Interviews with four representatives of SMEs conducted by Pirjo Kutinlahti and Kirsi Hyytinen in 2002	Perceptions of SMEs on the importance of university collaboration	Number of interviewees 4	IPR issues and constraints of university partnership
7) Expert workshop	Views on the "third function" of universities and especially their role in commercialisation of research.	Number of experts 11	Rationales for university engagement in commercialisation; IPR issues

Appendix 2: Surveyed university departments and research centres

Helsinki University of Technology, Centre for Energy Technology
Helsinki University of Technology, Department of Computer Science and Engineering
Helsinki University of Technology, Laboratory of Space Technology
Helsinki University of Technology, Ship Laboratory
Helsinki University of Technology, Transportation Engineering
Tampere University of Technology, Digital Media Institute
Tampere University of Technology, Institute of Material Science
Tampere University of Technology, Occupational Safety Engineering
University of Helsinki, Institute of Biotechnology
University of Helsinki, Department of Physics
University of Helsinki, Department of Computer Science
University of Helsinki, Department of Food Technology
University of Helsinki, Department of Geography
University of Helsinki, Department of Sociology
University of Helsinki, Department of Forest Economics
University of Helsinki, Department of Chemistry
University of Helsinki, Department of Psychology and Applied
University of Joensuu, Faculty of Forestry
University of Jyväskylä, Department of Physics
University of Jyväskylä, Department of Mathematics
University of Jyväskylä, Department of English
University of Oulu, Department of Biology
University of Oulu, Infotech
University of Kuopio, Department of Environmental Sciences
University of Kuopio, A.I. Virtanen
University of Tampere, Regional Studies and Environmental Policies
University of Tampere, School of Public Health
University of Turku, Turku Centre for Biotechnology
University of Turku, Department of Biochemistry and Food
University of Turku, Research Unit for the Sociology of Education

Appendix 3: Data and methodology of survey among small and medium-sized companies

1. Description of sources of company lists used in the VTT-survey[7]

The selection of companies to be surveyed was made according to expert judgement by researchers by picking up company names from different following source files as described below. According to expert judgement these companies were classified into three different kinds of SMEs as presented above. This taxonomy was taken from the Project Plan of this evaluation project (dated 17th June in 2002). The aim was to get approximately 30 returned questionnaires from each SME category. The sources of company lists are described in the next paragraphs.

(1) A fast growth SME targeting international markets (33 firms)

Most of the SMEs in this category were identified from the annual lists of 50 fast growing companies from the trade journal *Talouselämä* (years 1998–2001). The emphasis was on the SMEs that had export activities. These companies represent different sectors in industry and different areas in Finland as well. Some of the companies were picked up from Sfinno-database[8]. These companies have had innovation related activities in the late 90's (1995–) and according to the Sfinno- survey data their innovation has been new in the global markets and the export of the innovation has begun.

(2) A traditional industry line (SME) facing the task of integrating new technology into its established products on stable markets (34 companies)

In this category the companies were identified from Sfinno-database. These SMEs represents so called traditional industry sectors (foodstuffs, wood & paper & pulp products, metal products, machinery) which have in the Sfinno-survey questionnaire regarded scientific breakthrough or new technologies as significant sources of their innovations or universities or research institutes as a significant contributors to their innovation processes.

(3) A start-up company within a knowledge intensive business line (35 companies were surveyed)

[7] The data description is prepared by Jukka Hyvönen.

[8] Sfinno-database consists of some 1600 innovations commercialised in 1980's and 1990's by Finnish firms. These innovations were identified from trade journals, expert opinion panels and annual reports of large firms. The database includes basic data of all the innovations (the description of innovation, the year of commercialisation and the product group of innovation) and the firms commercialising them (industrial sector, the number of employees etc). A survey questionnaire was also conducted and approximately 860 questionnaires were returned. This survey questionnaire focused on the features of the innovation processes like co-operation in the development of innovations, the sources of innovations and the duration of innovation processes.

The companies in this category came from ICT-sector or biotech related services to meet the criteria for knowledge intensive business. They were identified from the portfolios of different public and private venture capitalists, like SITRA, Teknia Invest Oy, Bio Fund Management Oy, Innofinance Oy, Nexit Ventures Oy, Stratos Ventures Ltd. Oy, Teknoventure Managemenet Oy and OKO Venture Capital Oy. Some of the companies were identified from SPINNO-program and from the client lists of Teollisuussijoitus. All these companies were established in the late 1990's.

2. Objectives and data collection

The questionnaire of the availability and relevance of public services, aimed at supporting innovation activities of target companies, was compiled by a group of researchers at VTT Technology Studies (Torsti Loikkanen, Pirjo Kutinlahti, Juha Oksanen, Jukka Hyvönen and Bernd Ebersberger). The questionnaire consisted of following main items:

1. Background information and profile of innovative SMEs
2. Usage of services of public organisations concerned in companies
3. The usage of respective private services in companies
4. The assessment of benefits of public services to companies
5. Promoting factors and barriers of innovation activities of companies
6. Development needs competitiveness and innovation activities in companies and in general in corresponding industrial sector.

The interviews for survey are conducted by *Tietoykkönen Ltd* as computer aided telephone interview system during October and November 2002.

3. Characteristics of companies[9]

The oldest company in the sample has been founded in 1898 and the youngest companies are founded in 2001. Half of the companies are founded in 1992 and later. About 28% of the companies were founded in the late 1990s and the early 2000. The companies' average employment amounts to 68 people. The size of distribution in terms of employment is strongly skewed: about 50% of the sample population employ less than 20 people and 75% of the sample employs less than 70 people. The average turnover generated by the firms in the sample is 11.22 Mio €. 75% of the companies generate a turnover of 8 Mio € and less. The companies of the sample can be characterised by high R&D expenditure. The average percentage of turnover that is devoted to R&D in the sample is more than 19%. 75% of companies spend more than 3% of their turnover on research and development and 25% of the companies spend even more than one fifth of their turnover for R&D. The sample contains companies with strong focus on innovation. 96% of the companies reported to have carried out innovation activities.

[9] The characteristics of companies have been analysed by Bernd Ebersberger.

Published by

Series title, number and report code of publication

VTT Publications 589
VTT–PUBS–589

Author(s)
Kutinlahti, Pirjo

Title

Universities approaching market
Intertwining scientific and entrepreneurial goals

Abstract

University-industry interaction and the commercialisation of academic research have been subject to intensive debate during the recent decade. Entrepreneurial activities are included with the universities' 'third function' encompassing the economic development in addition to education and research functions. This study examines the nature and impacts of the entrepreneurial role of universities by focusing on university-industry-government relations and university engagement in commercialisation in Finland in the late 1990s and early 2000s. Using data from several surveys and interviews conducted among Finnish university staff and firms who participated in the EU framework programmes, the present study provides insights into the possible gains, losses and tensions determined by the entrepreneurial activity of universities. The study shows that scientific and entrepreneurial goals can be intertwined, although tensions and conflicts of interest may arise. The latter may emerge from the confrontation of different research cultures and normative structures, rather than because of the divergences between basic and applied research orientation. The book offers insights and understanding for anybody interested in the nature and impacts of the 'entrepreneurial' role of universities.

Keywords

entrepreneurial universities, academic research, knowledge creation, knowledge dissemination, knowledge exploitation, SMEs, academic rationale, economic rationale, societal rationale, innovation activities

Activity unit

VTT Technology Studies, Kemistintie 3, P.O.Box 1002, FI–02044 VTT, Finland

ISBN			Project number
951–38–6690–4 (soft back ed.) 951–38–6691–2 (URL:http://www.vtt.fi/inf/pdf/)			P2SU00154
Date	Language	Pages	Price
December 2005	English	187 p. + app. 4 p.	D
Name of project		Commissioned by VTT Technical Research Centre of Finland, National Technology Agency, Ministry of Trade and Industry	
Series title and ISSN VTT Publications 1235–0621 (soft back ed.) 1455–0849 (URL: http://www.vtt.fi/inf/pdf/)		Sold by VTT Information Service P.O.Box 2000, FI–02044 VTT, Finland Phone internat. +358 20 722 4404 Fax +358 20 722 4374	

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Tätä julkaisua myy

VTT TIETOPALVELU
PL 2000
02044 VTT
Puh. 020 722 4404
Faksi 020 722 4374

Denna publikation säljs av

VTT INFORMATIONSTJÄNST
PB 2000
02044 VTT
Tel. 020 722 4404
Fax 020 722 4374

This publication is available from

VTT INFORMATION SERVICE
P.O.Box 2000
FI–02044 VTT, Finland
Phone internat. +358 20 722 4404
Fax +358 20 722 4374

ISBN 951-38-6690-4 (soft back ed.)
ISSN 1235-0621 (soft back ed.)

ISBN 951-38-6691-2 (URL: http://www.vtt.fi/inf/pdf/)
ISSN 1455-0849 (URL: http://www.vtt.fi/inf/pdf/)

VTT PUBLICATIONS 589 Universities approaching market. Intertwining scientific and entrepreneurial goals Pirjo Kutinlahti