Science and Society - Building Bridges of Excellence
Perceptions on the Interaction between Public Research and Enterprises
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Perceptions on the Interaction between Public Research and Enterprises

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Foreword

The position of science has changed in recent years. Together with the emergence of the knowledge-based society the role of academia has become more significant and at the same time demands for accountability have increased considerably. This development reshapes the institutional arrangements among universities and research institutes, industries and governmental agencies.

As the role of knowledge producing institutions is perceived and recognised in socio-economic contexts, an increasing number of universities and public research institutions adapt to the new framework. At the same time governments and policymakers ask for more information on the interaction between private and public research, how to evaluate and monitor the relationship and how to establish good practices.

The present report analyses the linkage between academia and enterprises seen from the perspective of enterprises. It highlights some overall features that enterprises are facing in connection with cooperation with universities and other public research institutions. The report consequently aims to assess the role of framework conditions that influence the relationship between the public and the private sector. The report further points to ways and means to improve the relationship.

The report is an integrated part of the REMAP (Research & Development Management Processes under Rapid Change) project - a research partnership between The Department of Management, Politics and Philosophy (Copenhagen Business School), The Danish Institute for Studies in Research and Research Policy, RISØ National Laboratory and six research based Danish companies. REMAP has an interdisciplinary approach that bridges the gap between theory and application, practice and learning, knowledge accumulation, education and the main institutional actors in the triple helix; i.e. the relationship between higher education institutions, industry and government.

On behalf of the Danish Institute for Research and Research Policy I would like to thank the managers and research leaders of enterprises and organisations, which have participated in this project, for sharing their thinking with us. I also like to thank Elisabeth Vestergaard and Dan Mouridsen for their valuable contribution to instrumentation and data collection.

Karen Siune
Director
November 2003

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PART I

1. Aims and Objectives

As the ever more important role of knowledge producing institutions is perceived and recognised in socio-economic contexts, an increasing number of universities and public research institutions adapt to the new frameworks. Governments and policymakers ask for more information on the interaction between the public and the private sector, how to evaluate and monitor the relationship and how to establish good practices.

The study presented here aims to analyse the linkage between academia and enterprises seen from the perspective of the enterprises. The study consequently highlights some overall features that enterprises are facing in connection with cooperation with universities and other public research institutions.

The main objectives of the study are to provide:

- A mapping of managers' attitudes on and perceptions of the relationship between academia and enterprises.

- Information on the barriers impeding more intensive and widespread interaction between academia and enterprises on the one hand and suggestions on how to overcome these barriers on the other.

- Information and suggestions on general conditions that promote and intensify the interaction between academia and enterprises.

Moreover the study has the ambition to provide information to policymakers on how to develop framework conditions that further stimulate the interaction.

2. Background

The position of science in emerging knowledge-based societies has changed. The role of academia has become more significant and at the same time the demands for accountability have increased considerably. This development reshapes the institutional arrangements among universities and research institutes, industries and governmental agencies. Science and research are perceived in their socio-economic contexts and organisations, networks, communication and interaction patterns between scientific institutions, industry and governmental bodies are transforming in order to respond to the new socio-economic challenges.
This transformation, which public research institutions in developed economies have experienced during the last decade, particularly with regard to their roles and responsibilities in RTD (Research, Technology & Development) and innovation systems, creates new types of relationships that are subject to international debate (see Nowotny et al. 2001, Etzkowitz & Leydersdorff 2000, Gibbons et al. 1994, Ziman 1994).

The debate on this issue has consequently raised questions such as: is it plausible to orchestrate the interaction? If this is the case, what may be the instruments to achieve this[1]?

To find adequate answers in this context, attention should be given to the viewpoints of enterprises on how the relationship has been in Europe and otherwise. Moreover it is important to identify what is required in order to increase communication, networking and collaboration between academia and enterprises.

In Denmark, industry has a tradition of presence in the overall RTD and innovation system[2]. However the resources used on RTD activities in the industrial sector show great differentiation. Even the extent of networking and collaboration activities between private and public funding research institutions show differentiation. Larger RTD intensive companies with established research departments have more interaction with universities and other public research institutions (Graversen at al. 2003).

Recent quantitative research in the field confirms that private enterprises with well-established collaborations with public research benefit from this as they have a series of competitive advantages to those without. RTD activities for these

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[1] The linkages between the public and private sector has become an issue for policymakers and concentrated efforts to find a more effective utilisation of science and technology results.

[2] See The Danish Institute for Studies in Research and Research Policy WP 2002/14 and Report 2003/5.

enterprises are evidently less costly and more efficient[3]. A study of perceptions of 600 managers of private businesses on the issue of public research produced in Denmark, and the significance of this research for their enterprises, reveals that approximately 40% considered knowledge from public research institutions of major importance. Nearly 60% of these enterprises (those with actual collaboration with public research institutions) point out as well that the knowledge produced with public funding is of major importance for the companies. This group of managers consequently requested a strengthening of ties with public research, more information on research from public institutions and a strengthening of public research in general[4].

The findings are supported by other studies, which conclude that research managers and researchers at universities and public sector institutes in general have a positive attitude to increased cooperation with enterprises (Graversen et al. 2002, Langberg 2001, Lauridsen 2002). A recent study of dynamic and innovative public research environments in Denmark illustrated that by far the majority of these environments had established networks and cooperation with the private sector (Graversen et al. 2002).

Consequently, the above-mentioned studies have confirmed an interaction between the private (although mainly larger companies) and the public sector. They have illustrated the positive attitudes of public researchers towards cooperation with enterprises as well. The main issue is hence to find reasons for an evident absence of more widespread interaction, potential barriers to it and how to overcome such. These elements are the focus of the present report.

The report is an integrated part of the REMAP (Research and Development Management Processes under Rapid Change) project. The REMAP project is a research partnership between The Department of Management, Politics and Philosophy (Copenhagen Business School), The Danish Institute for Studies in Research and Research Policy, RISØ National Laboratory and six research based Danish companies. The co-operation aims to develop an integrated model for understanding, managing, prioritising and evaluating complex research and development processes in public and private R&D. In particular the REMAP project focuses on the identification of various complementary selection criteria and tools necessary for an early assessment of knowledge creating processes. The project has an interdisciplinary approach, which bridges the gap between theory and application, practice and learning, knowledge accumulation, education and the

[3] The Danish Institute for Studies in Research and Research Policy WP 2002/14 (Graversen et al. 2002).

[4] The Danish Institute for Studies in Research and Research Policy WP 2002/3 (Mortensen 2002).

main institutional actors in the triple helix; i.e. the relationship between higher education institutions, industry and governmental agencies.

The long-term perspectives of the project offer research policymakers, public researchers and private companies an opportunity to understand the complexities underlying R&D management and how to apply appropriate methods and evaluation procedures.

3. Methodology Approach and Structure of the Report

The study is based on (a) a presentation of important theories and discussion of different perspectives on the public research – enterprises relationship, and (b) an analysis of in-depth interviews with 31 managers of mainly private companies, but also with private companies research leaders and leaders of non-profit organisations. The study focuses on selected prominent enterprises with intensive research activities and experiences from cooperation with public research in Denmark and abroad.

Results of the study are compared and validated - where possible - with the results of a recent quantitative study of 600 Danish enterprises[5]. The quantitative study functioned as a complement to the present study that has a qualitative approach. Similar studies by OECD (2002), EU and The Austrian Federal Ministry of Economy and Labour (Polt et al. 2001) have also been taken into account and used - where appropriate - as references.

Consequently the report comprises two parts. In part I different perspectives of the academia – enterprises relationship are discussed. A historical perspective of the relationship and some theoretical reflections are presented in sections 4-6. The framework conditions for the relationship (as these are presented in the literature of science) are discussed and the most important public science policy initiatives in Denmark are presented in sections 7-8.

The main results of the qualitative study and analysis are given in part II, in section 9, together with suggestions for improvement of the relationship. Section 10 illustrates the implications of scientific cultures and norms for the relationship between public research - enterprises, followed by a general discussion in section 11. Implications for research policy are presented in section 12. Finally an executive summary is available at the end of the report.

[5] The Danish Institute for Studies in Research and Research Policy 2003/5 (Graversen et al. 2003).

4. Interaction Academia – Enterprise: A Historical Perspective

Industry-academic links go back to the late 19th century (see, for example, the close linkage between German universities and the chemical industry) and represent the main mechanism for industry to funding public research.

Under the late 19th century the world witnessed an academic revolution as research was introduced into the university as a complement to teaching (the "first academic revolution").

In recent times the increasing significance of research to socio-economic development has led to a re-evaluation of the role of universities in society and opened up for a third mission, the contribution of the universities to socio-economic development, the "second academic revolution". The third mission of the universities encompasses mainly an option to develop knowledge *together* with society and doesn't merely put a boundary on the transformation of knowledge to the rest of the society (Etzkowitz & Leydesdorff 2000).

Even though linkages go back a long time and were strong already during the 19th and 20th century, the interest in a closer link between academia and enterprise has nowadays become broadly recognised and is a target of national and European science policy. This development was initiated in the 1970s and continued during the 1980s and 1990s. The inspiration came from the US where many universities have developed close relationship with industry and growth rates can be attributed to this relationship amongst others (Martin 2002).

Linkages between universities and enterprises were the result of four main mechanisms and sources. *Firstly*, the linkage appeared in the course of informal contacts and spin-outs from universities; *secondly*, from research collaboration and contracts performed by universities on behalf of industry; *thirdly*, as a result of specific initiatives such as the establishment of science parks; and *fourthly* in connection with commercialisation and exploitation of public research through management and licensing of intellectual property rights. European countries have closely followed the US as being at the forefront of economic growth and development of university-enterprise relationship, and as a result (especially during the 1980s) some countries adopted and further developed these mechanisms (Howells et al. 1998).

Today, it is a fact and is taken for granted that universities and other public research institutions have a major role to play in transferring knowledge, supporting innovation and interacting with their socio-economic environment at regional, national and European levels.

Establishing linkages between universities and enterprises has not been without problems though. It has generated tensions and conflicts of interests and commitment between people involved in the partnerships. Such problems must be addressed and overcome. As conflicts diminish over time, a new basis for relationships emerges and new organisational and managerial models are utilised (Etzkowitz 2000).

In a historic perspective tensions were supposed to arise from the prospect that academic staff could be distracted from their research by excessive enterprise-directed work (see OECD 1970). However, research results have demonstrated that the strongest and most productive relationships with private enterprise are found upon public research institutions doing what these are best capable of and have competence to do, namely to produce excellent research, rather than attempting to duplicate the functions of industry. The challenge is hence to provide the relationship with a gate or an interface which facilitate interaction, effective mobility of people and flow of knowledge to their most productive use (Graversen et al. 2002, Howells et al. 1998)

Focusing on Denmark, it is obvious that science policies to promote the linkage between academic research and private enterprise were introduced rather late compared to other European countries like UK and Sweden, and only as a supplement to informal contacts and occasional contracts. The mechanism of collaborative research between universities and industry was introduced in the last decade but was recently intensified, also through participation in the European Framework Programmes.

As one consequence of this, Research Councils were reorganised and had to redefine their missions, also in order to encourage this interaction. Legislation now has to change in order to shape an adequate framework for collaborative activities.

Research policy initiatives in 1999 introduced an act on inventions at public research institutions that transferred researchers' individual rights on inventions to an institutional level. According to this, researchers at universities and other public institutes are obliged to inform their institution of potentially patentable or otherwise commercially exploitable research. In addition, researchers are constrained from publishing the results for up to two months until the institution decides whether or not to exploit the results commercially. In 2000 the so-called "development contracts" concept was introduced between the Ministry for Research and the universities. These contracts focussed on success criteria and the assessment of output as an instrument in science policy. The new reform of the universities, presented recently by the government, also addresses the issue of cooperation between universities, other public research institutes and industry, and stresses the

need for stronger links between the public and the private research sector. A more detailed discussion of the Danish research policymaking follows in section 7.

Nevertheless, as research demonstrates, the establishment of the industry-academia link and the development process has not followed a single, direct pathway but is the sum of a wide variety of initiatives taken at every level in society (Howells et al. 1998).

5. The Overall Framework of Research - Some Theoretical Considerations

In a historical perspective, universities build on the classical Humboldtian perception of the role and function of the university that has been spread from Germany to other countries the last two centuries although with some exceptions (France, Eastern Europe). According to this perception, funding of research by the state is essential to the university. High levels of autonomy for both individuals and institutions with academics free to engage in research and free to choose research area and topic, characterise the ideal Humboldtian university. In the same line, universities in the classical perception are free to determine the allocation of resources across disciplines and departments (Martin 2002).

The same paradigm was considered also in the US after World War Two. However, another model was introduced (Bush 1945) that became successful during the time period 1945-1990. The introduction of this model resulted in large increases in governmental funding, trained scientists and research outputs. Essential characteristics of this model, used primarily in the US and later on in other countries, are a high level of autonomy for science, a conviction that basic research is the responsibility of government and is done best at the universities, and a high degree of institutionalisation of peer review in connection with allocation of resources. According to this, a linear model of innovation sets off with basic research that leads to applied research and development and ends up in innovation (Martin 2002).

However, the increasing importance of scientific competencies, the increasing global competition and emphasis on innovation and the knowledge-based economy in combination with constraints on public expenditure, have brought great changes in the traditional models of funding innovation and development. Growing demands for accountability, effectiveness, relevance, value for money and justification for government funding of science are changing the contract between science and society. Science and technology knowledge is increasingly becoming a strategic resource for companies, regions and countries.

Hence, it has recently been emphasised in the literature of science, how the relationship between science and society has changed dramatically during the last decades. The transformation of the relationship has been addressed in a number of publications[6].

One of the most significant theories presented in the publications The New

[6] Gibbons et al. 1994, Ziman 1994, Etzkowitz 2000, Novotny et al. 2001.

Production of Knowledge (Gibbons et al. 1994) and Re-thinking Science (Nowotny et al. 2001) is the **Mode 2** concept where, as the authors argue, a new paradigm for science has been introduced. According to this, the process of knowledge production and research practice is changing fundamentally. These changes in the constitution of science and in research practice are attributed to the growing contextualisation and socialisation of knowledge. According to the theory, knowledge is now generated in the context of application.

The implications according to the theory are that science can no longer be regarded as an independent entity, demarcated from society, but depends on how the context within which it operates is defined. The organisation and functioning of the overall research system is changing and a new social contract for science is emerging, as society has increasing demands to science and research. Science has always provided society with a continuous flow of knowledge on how to conceptualise the physical and the social world. The difference is that nowadays society “speaks back” to science. Science is now listening as ”Mode 2 society generates the conditions in which society is able to `speak back` to science; and that this reverse communication is transforming science. Contextualisation is invading the private world of science, penetrating to its epistemological roots as well as everyday practices, because it influences the conditions under which `objectivity` arises and how its reliability is assessed” (Nowotny 2000).

According to the **Mode 1** concept new knowledge was produced primarily through disciplinary research mainly in universities and academic research institutes. Such knowledge usually had only some degree of connection to societal requirements and needs. Results were transferred to users after the research process was finished. Consequently, according to Mode 2 concept, Mode 1 showed only limited societal accountability being the result of efforts to preserve maximum autonomy of research and universities.

In Mode 2 a fundamental shift towards a new mode of knowledge production occurs where new knowledge is produced through trans-disciplinary research in a variety of research institutions. This is made in the context of application, and is directly influenced by societal needs with users often involved from the beginning in the knowledge producing process. In this perspective, societal accountability for public funding is central, as changes in knowledge production should be reflected in the public support of research, according to the theory.

Other researchers claim that there is little systematic evidence that the Mode 2 concept is new (David et al. 1999, Martin 2002). These argue that Mode 2 has always existed and is a complement to publicly funded and validated research but has been intensified during the 1990s. A shift in balance from Mode 1 to Mode 2

concept is so noticed in the last part of the 20th century. According to others (Godin & Gingras 2000) the share of Mode 1 in knowledge production has increased, rather than the opposite.

Ziman (1978 & 2000) on the other side describes how science has been going through a structural transition to a more tightly organised, rationalised and managed institution and emphasises the issue of reliability of science in this context. According to Ziman, scientific knowledge can be distinguished from other intellectual artefacts of human society by the fact that its contents are *consensual* (asks for a maximum degree of agreement) and *consensible* (is comprehensible to others). Through the operation of the dual processes of consensibility and consensuality within the relevant peer group, science becomes able to produce reliable knowledge. In accordance to this epistemological model, science produces reliable knowledge if the rules - which guide research practice - are followed. Ziman argues that Mode 2, in comparison to Mode 1, may also incorporate traditional scientific values. However, Mode 2 research is an activity where socio-economic power is the final authority, argues Ziman (2000).

5.1. Research Systems, Socio-Economic Context and the Triple Helix Concept

Focus in this section is on the university-industry-government relationship and how this is perceived in the literature of science. Different models explaining this relationship are presented in order to highlight the research system in its socio-economic context.

One such model, the so-called **triple helix** model provides a framework for understanding the institutional arrangements of university-industry-government relations. The triple helix takes as its point of departure two standpoints (a) an *etatistic* model of government controlling academia and industry (see figure 1) and (b) a *laissez faire* model, with industry, academia and government separate from each other, interacting only modestly across their boundaries (see figure 2).

According to the triple helix model universities can play an enhanced role in innovation processes in knowledge-based societies. This approach is different from *the national system of innovation model* (Lundvall 1988 &1993, Nelson 1993) and differs also from *the "triangle" model* presented by Sabato and Mackenzi (1982). The first model considers the firm as having the leading role in innovation while the second model recognizes the state as being privileged in the relationship university-industry-government (see Etzkowitz & Leydesdorff 2000).

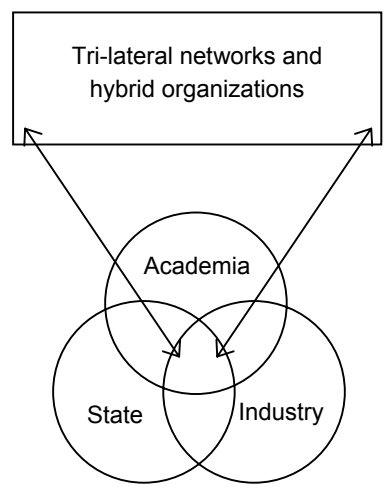
Etzkowitz & Leydesdorff (2000) distinguish between *three policy models* of the triple helix concept. In *triple helix I* (figure 1) the nation states encompass industry and academia and direct their relationship. Triple helix I has been working in some countries until quite recently. This could be found (in its strongest version) in the former Soviet Union and until some years ago in other Eastern European countries. Indeed, a process of transition has been identified in Eastern Europe from triple helix I to triple helix II in the early post-socialist period and forward to triple helix III from the mid 1990's. Weaker versions of triple helix I could be identified in the policies of many Latin American countries, and to some extent in European countries too, such as France and Norway.

Triple helix II (figure 2) consists of separate institutional spheres with limited interactions across the borders of academia, industry and government. Triple helix II could be found in Sweden (see Research 2000 Report) and in the US.

Both of the previous mentioned formats are in transition to triple helix III, a more flexible innovation format, according to Etzkowitz & Leydesdorff (2000).

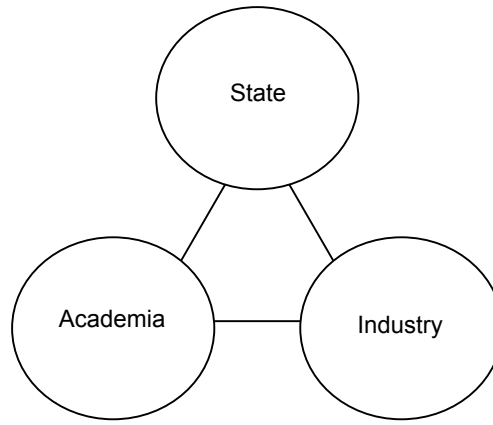
Triple helix III is generating a knowledge infrastructure in terms of overlapping institutional spheres, where each one is taking the role of the other (shaping tri-lateral networks) and where hybrid organisations are emerging at the boundaries of academia, industry and state (see figure 3).

Figure 1. Triple helix I model of university–industry–government relations.



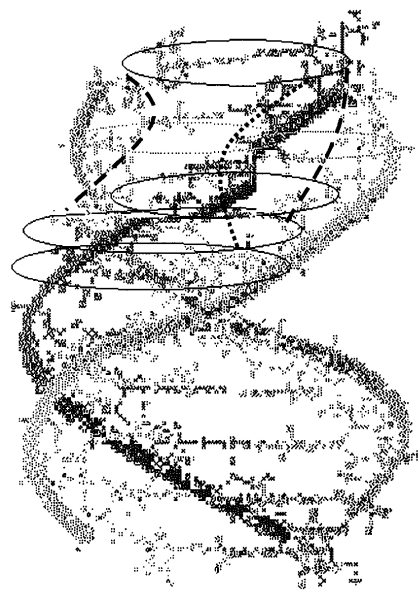
Source: Etzkowitz & Leydesdorff (2000).

Figure 2. Triple helix II. A "laissez-faire" model of university–industry–government relations.



Source: Etzkowitz & Leydesdorff (2000).

Figure 3. Triple helix III. The overlay of communications and expectations at the network level guides the reconstruction of institutional arrangements.



Source: Etzkowitz & Leydesdorff (2000).

The triple helix as an analytical model describes the variety of institutional arrangements and policy models and provides an explanation of their dynamics. According to Etzkowitz & Leydesdorff (2000) triple helix I is regarded as a failed development model that does not give room for "bottom up" initiatives and cannot encourage innovation. Triple helix II encompasses a laissez-faire policy adopted in order to reduce the role of the state in triple helix I. However, most countries are nowadays trying to attain some form of triple helix III.

The objective in a triple helix III model is to create an innovative environment that consists of university spin-off firms, strategic alliances among enterprises, governmental laboratories, academic research groups and trilateral activities for knowledge-based economies. These initiatives are encouraged and often assisted, but not controlled, by governments.

In the knowledge-based society, the university becomes a key element of the innovation system both as human capital supplier, research producer and dissemination agent, and as the source for creating and developing new firms. Three spheres (state, private and academia) are gradually more interwoven with a spiral pattern of links emerging at different stages in the innovation process (Etzkowitz & Leydesdorff 2000).

5.2. Earlier Studies and the Future of the University

From the literature of science and the European, national and regional policy agenda it looks like the whole system of knowledge production is in transition, with more or less constant reconfigurations between various interests and sectors. Theories on "national systems of innovation" (Lundvall 1988, Nelson 1993), theories on "research systems in transition" (Cozzens et al. 1990, Ziman 1994), Mode 2 theories (Gibbons et al. 1994) or theories on "the post modern research system" (Rip and Van der Meulen 1996) are indicative of flux, reorganisation, and the enhanced role of knowledge in the socio-economic system.

It is claimed in the literature, as discussed earlier, that science is changing, universities are changing, and that Mode 2 is replacing Mode 1 in knowledge-based societies (Gibbons et al. 1994, Nowotny et al. 2001). In general, there are different views on the prospects of universities as central actors in such societies.

Some researchers are sceptical or even opposing, others have more positive attitudes on the implications of universities' external orientation, changed funding base and, interaction and influences from industry. Critical voices such as Geuna (2001), Slaughter & Archerd (2001) and Slaughter & Rhoades (1996) argue that

the consequence of this may be a decrease in long-term research and increased pressures on and dilemmas for researchers when choosing fields and subjects. Other researchers as Ziman (1991) argue that academic involvement with industry is an indicator of a transformation of the university to a bureaucratic mode. In this bureaucracy, academic research will mimic its industrial counterparts, controlling the decisions on how to do research, but having lost control over the research agenda to external interests.

On the other hand, Kleinman & Vallas (2001) argue that the meeting between academic and corporate research may imply increased flexibility and autonomy for researchers. The triple helix literature has though a more optimistic view of the prospects of universities and researchers within the organisations emerging at the interfaces of overlapping institutional spheres (Etzkowitz & Leydesdorff 1997).

Having as a starting point the intensive debate on new types of knowledge production and the increased political focus on university-industry relations, a number of studies in the field have been carried out the last years[7].

Many of the investigations are based on case studies of one or several countries, universities or new technology transfer organisations like science parks. Quantitative data are generally missing, and there is little longitudinal evidence about changing relationships other than macro-level figures on changes in the funding structures (see Brenner & Sandström 2000, Gulbrandsen & Smeby 2002) or studies of research management at the macro or institutional level (Ernø-Kjølhede et al. 2000, Graversen et al. 2002)). In addition, empirical studies (Gulbrandsen 1997, Godin 1998) reveal that the most important links between universities and industry, and the traditional "mode" of cross-sector co-operation during the main part of the 20th century, could be found at the *individual* level, in informal contacts between professors and researchers/managers in industry.

According to Etzkowitz & Leydesdorff (2000), there are *four processes* related to main changes in the production, exchange and use of knowledge which the triple helix model has identified: the *first* is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of an economic development task by universities. The *second* is the influence of one institutional sphere upon another that results in transformation (an example is revising rules of intellectual property ownership to transfer rights from individuals or government to the universities/institutes, as is the

[7] Many of these studies have been discussed at triple helix conferences and presented in journals such as Science and Public Policy (vol. 26 and 28), Minerva (articles from 1996 to 2001), VEST (vol. 13 no. 3-4), Research Policy (vol. 29) and Journal of Technology Transfer (vol. 24).

case in Denmark). The *third* is the creation of new boundaries of trilateral linkages, networks, and organisations among the three spheres. This stimulates organisational creativity and regional cohesiveness. The new interfaces are leading to new ideas and joint projects that might not otherwise have emerged from interaction within single spheres or from bilateral relations. The *fourth* process is the recursive effect of inter-institutional networks both on their originating spheres and the larger society.

Etzkowitz & Leydesdorff (2000) claim that one effect of the inter-institutional networks representing academia, industry and government is on science itself. This is a result of internal changes within academia strengthened by government policy. Given the increased participation of academics in entrepreneurial activities (and what the authors call “the failure to define this new role as abnormal”) the authors conclude that the capitalization of knowledge appears to take increasing preference over disinterestedness as a norm of science (see Merton 1942, Etzkowitz 1998). According to Etzkowitz & Leydesdorff (2000), normative changes have taken place not only as a result of the emergence of an entrepreneurial dynamic within academia but also from external influences on the university.

Etzkowitz et al. (2000) and Benner & Sandström (2000) argue that research funding and research funding organisations create “organisational fields” that over time affect the routines, norms and organisational structures of researchers and their institutions.

As a consequence, some fundamental questions arise: if science and research are changing (as the above-discussed literature argues) that must imply that scientists and researchers have changed also in their behaviour and/or attitudes. If the interaction of triple helix is in transition from Mode 1 to Mode 2, then industrialists/entrepreneurs as well as policymakers and funding agencies have changed in their behaviour and attitudes. If universities have changed in the process of interaction with other sectors and actors, industries have changed too in order to meet the demands of the new environment. A central question is accordingly whether the emergence of science parks, linkage units, patenting and licensing offices, other organisations and science policymaking opened the way to a new mode of knowledge production and new (and probably more intensive) ways of collaboration between universities and enterprises.

The Mode 2 concept and triple helix III model of interaction are popular with policymakers, but have changes in the ecology of science been followed by changes in norms, attitudes and behaviour among researchers? And have these been followed by changes in attitudes and behaviour in the private sector?

Another central issue is in which degree it is possible for academia to combine Mertonian norms and values, and entrepreneurial norms and values in a paradigm of entrepreneurial science in which the traditional *dissemination* and the *capitalisation* of knowledge are made more compatible. The tensions between the utilisation of knowledge, in order to maximise public good and controlling its value as a private good are still present[8]. The central issue for research on science is: Have norms, attitudes and behaviours really changed in the triple helix interaction between enterprises, academia and government (as claimed by some researchers) and if this is the case, how?

5.3. Towards the Responsive and Entrepreneurial University

The effect of the above-mentioned four processes, introduced by Etzkowitz & Leydesdorff (2000), has been the emergence of a new entrepreneurial culture on the academic scene, according to the authors. The introduction of entrepreneurial activities in academia affects the educational and research tasks of many institutions of higher education, although in various degrees.

Universities, as mentioned earlier, must undergo a "first academic revolution" i.e. the incorporation of a new task namely research as an academic mission. According to some theories, academic institutions have already, or are forced to enter, "the second academic revolution" i.e. the assumption of a role in the socio-economic development through extensions of both their research and teaching missions. The result is or might be a more responsive and/or in a higher degree entrepreneurial oriented university.

Burton Clark (1998) argues in "Creating Entrepreneurial Universities" that universities have to take back the initiative in the current economic situation, make available funding from external resources and share such resources with others that have no access to external sponsorship. Clark perceives the entrepreneurial university as one having the ability to generate strategic direction, formulating at the same time academic objectives and transforming knowledge into economic and social utilisation.

According to Etzkowitz et al. (2000), the entrepreneurial university includes the following developmental mechanisms and structures, and have implications that can be tied to the four processes mentioned in the previous section, that are related to changes in the production, exchange and use of knowledge in the triple helix concept.

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[8] For a more detailed discussion on tensions in knowledge production see Arrow 1962, David & Foray 1995, Foray 1997.

Firstly, universities are undergoing an *internal transformation*. Traditional academic tasks are redefined according to requirements of emerging functions. The consequence of this is a revision of existing tasks. Traditional functions and roles are redefined and expanded in order to reach new objectives. The new role of the university emerges though controversies such as the transformation of the academic mission from dissemination to capitalisation of knowledge. The debate on these issues is intensive, first and foremost within academia but also in society at large. Out of the controversies new rules and roles are defined and legitimated. Over time many universities might redefine their mission to better incorporate the entrepreneurial paradigm.

The second aspect concerns the *trans-institutional setting*. Industry and government develop similar capabilities. The imbalance between organisations and institutions that have such capabilities and those that lack them are nowadays seeking to be restored. A new balance of overlapping institutional spheres is established in which the rules for interaction are understood and negotiated without great difficulties. The consequence of this is stabilisation. Interaction and collaboration channels are institutionalised and contracts are established.

The third aspect concerns the *interface processes*. The entrepreneurial university calls for a capability for intelligence, monitoring and negotiation with other institutions in industry and government. Beyond the engagement of the top leadership of the university, a mid-level organisational linkage that gives the university the ability to identify common interests with external organisations needs to be established. This implies that interface specialists enter the scene. Specialists make introductions, negotiate contracts and act as mediators in order to facilitate interaction with their counterparts and other institutions in government and industry. The consequence is centralisation in the first place but decentralisation in the long run. Over time, as the entrepreneurial paradigm takes hold, interface capabilities (such as technology transfer or university spin-off offices), playing a central role in the introduction of the entrepreneurial paradigm, are going to spread throughout the university and their role gradually decline (Etzkowitz 2000).

Finally, the entrepreneurial university also develops *capabilities* to assist the *creation of new organisations*. This usually takes various forms such as building of firms based on research and/or taken initiatives in forming regional organisations. The results are trilateral organisations, cross-organisational and cross-institutional units such as centres constituted by researchers from several universities or from universities, companies and other government institutions but also from joint ventures.

These are the essential characteristics of the entrepreneurial university and its process of emergence in the triple helix context, according to Etzkowitz et al. (2000). An illustration of the relationship of the triple helix in form of a summative chart of the university-industry-government relationship is presented in figure 4.

Figure 4. Summative chart of the university–industry–government relationship (adapted from Etzkowitz et al. 2000).

University		**Industry**		**Government**	
Subjects	Keywords	Subjects	Keywords	Subjects	Keywords
Academic culture	• Academic autonomy	*Industry Culture*	• Industry Goal	*Public policy*	• Government goal strengthen economy
1. Quality 2. Freedom to publish • Revision of acad. norms				1. Profit 2. Royalties • Revision of industry norms • Recognised economic Development as academic (extension) and industry function	
Academic function: teaching, research and extension		Industry function: national development			
Inputs: government funds and industry sponsorship Outputs: knowledge prod.		Inputs: knowledge Outputs: new products			
• Time to research • Commercialization of PSRS		• Generation of dynamism • Larger and faster technological innovation		• Give support to research directed to market • Give support to technol. innovation integrated to academic research	
1. Types of commercialization 2. Problems with commercial. 3. Results of the academic-industry technology transfer					
• Niches of market		• Niches of market		• Give support to university and industry identify niches of market	
• Exploitation of knowledge-based (academic expertise)		• Magnification of knowledge-base		• Economic development	
• Internal policy of patents		• Internal policy of patents		• Government policy of patents	
• Stability in the execution of research		• Sponsorship		• Give support to sponsored research	
• Use legal instruments to encourage cooperation		• Use fiscal incentives to encourage cooperation		• Give legal instruments and fiscal incentives to encourage cooperation	
• Evaluation of teachers that work with cooperation		• Evaluation of employees that work with cooperation		• Evaluation of university and industry results	

University		**Industry**		**Government**	
Subjects	Keywords	Subjects	Keywords	Subjects	Keywords
Intermediate offices • Function: connect teaching, research and extension resources administration internal marketing and communication external marketing administration of the Interaction process • Organizational structure		*Agents* • Function: connect in-home P&C with university P&D resources administration internal communication to evaluate possibilities of interaction and industry possibilities administration of the Interaction process • Organizational structure		*Politicians* • Function: stimulate interaction university-industry	
Relationship Evaluation	• Typology	*Relationship Evaluation*	• Typology	*Relationship Evaluation*	• Typology
New University 21st century university 1. Entrepreneurial university 2. New university mission: economic development 3. New organ. structure: mixing disciplinary departments, new disciplines, self- generation institutions, social space increased		*Industry* 21st century industry 1. Industry-based science 2. New industry mission 3. New organ. structure: cooperation projects, entrepreneurial centers of high technology in the vicinity of universities		*Government* 21st century government New government administration where scientific and techno logical infrastructure are integrated to the productive structure	

According to this perspective in the capitalisation of knowledge there are two dynamics at work: Firstly, there is an extension of university research into economic development, and secondly there is an inclusion of industrial research and its objectives and practices into the activities of the universities. These activities have, to begin with, been isolated and took place only sporadically. Later on, according to Etzkowitz et al. (2000), activities become integrated into each other and build centers that set up incubator facilities or establish liaison offices. The tendency of commercialisation of academic research is a result of developments of institutional capabilities to better administer research services but also a result of a change in the motivation of university researchers and managers (cf. Benner & Sandström 2000).

Other researchers have introduced the concept of *service university* in order to mark the differentiation from the traditional research university. Cummings (1997) distinguishes accordingly between the research and the service university. The research university that is anchored in the traditional disciplines and has been the

ideal around the world is facing a crisis of legitimacy, according to Cummings. The service university on the contrary will excel in service rather than conventional academic research. “Service is defined here as the delivery, installation, and maintenance of knowledge-based applications to clients wherever they may be” (Cummings 1997). Some characteristics of the service university compared to research university are summarized and presented below.

Research University	Service University
• Arts and sciences centered	• Professional schools
• Two-tier + instructional programme	• Post-baccalaureate degree & training programmes tailored for clients
• Year long courses	• One-week to four months courses
• Life-long personnel	• Non-tenured personnel
• Research organisation layered on top of teaching organisation	• Service carried out in parallel units
• Decentralised choice of research agenda	• Central planning and contracting of service
• Funding by grants and gifts	• Funding by contracts

Contextual factors such as national characteristics are of significance for the likelihood that universities will stress service, according to this viewpoint. Important contextual factors may be: the economic situation, a general sense of crisis and re-examination of allocations for higher education and research, the autonomy of research and issues such as leadership/management crisis. Other contextual factors of significance may be visions, building up of support and consensus, introduction of new activities, new structural initiatives, new financial procedures and outcomes. These settings are some of the preconditions for changes in academia and the basis for the emergence of a service university.

6. Norms, Cultures and Traditions in Academia

Norms, cultures and traditions are important mechanisms of influence in academia. Norms and traditions are of specific relevance in the study of the relationship academia – enterprise as these build the framework for joint research activities. There is a long tradition in the sociology of science to focus on norms, values and attitudes of the scientific community that influence activities and researchers' behaviour.

As early as 1942 Merton presented his theory on the significance of values and norms in science. The first norms described by Merton were: *universalism* (science is universal and the criteria for good science are not dependent on individuals but based on observations and accumulated knowledge), *communism or communality* (as Storer in 1966 renamed it to, implies that the products of science are common assets and should be accessible for all), *disinterestedness* (researchers are not driven by their personal interests and are emotionally detached from their research field) and *organised scepticism* (researchers have an obligation to criticise the work of colleagues). Some years later Merton (1957) added *originality* (the rationale of research is the extension of certified knowledge) and *humility* (learn from colleagues, recognise and respect them) to the norm concept. Barber (1952) extended the concept to include *rationality* (science aims to understand the world in abstract terms) and *emotional neutrality* (scientists are not emotionality engaged in their work). Storer (1966) added *objectivity* and *generality* to the concept of norms in science. According to the Mertonian tradition, norms are the normal state of science. Consequently, any other condition is perceived as abnormal.

The Mertonian norms were adopted during the 1950s and for the most part of the 1960s and provided the institutional context for the ethos of science. These norms were the ideology of science during this period. Critics argue though that Mertonian norms are describing the ideal and not the real world of the scientific community.

Based on a study of scientists involved in the American Apollo moon program, Mitroff (1974) formulated a set of counter-norms: *rationality* and *non-rationality*, *particularism*, *interestedness*, *solitariness*, *organised dogmatism* and *emotional commitment*. Counter-norms could be as plausible and genuine as Merton's norms, argued Mitroff. In general, in the Mertonian tradition, research is perceived as independent of the individual who is carrying it, while Mitroff perceives it as dependent on the individual scientist. Nevertheless, the two sets of norms are not excluding each other but operate differently in different situations. "Science contains norms and counter-norms. Both, however, do not operate equally in every situation" and "Whereas the conventional norms of science are dominant for well-

structured problems, the counter-norms proposed here appear to be dominant for ill-structured problems" (Mitroff 1974).

According to Mitroff, research in well-defined problems, that are clearly formulated and where there is a consensus among researchers on the way to solve these, the classic Mertonian norms are likely to be dominant. On the other side ill-defined problems are more linked to the person carrying them and consequently to the counter-norms.

Critics claim that the Mertonian norms represent an understanding of science that is rooted in *academic research*. Ziman (1994) on the other hand suggests a norm set containing *proprietary*, *local*, *authoritarian*, *commissioned* and *expert work* that is characteristic for *non-academic research*.

The norm sets presented above indicate different career patterns for researchers. The Mertonian norms are associated with *individual careers* based on personal scientific reputation and prestige and the perception of research as owned by the researchers. The set of norms presented by Ziman is associated with *organisational careers* based on researchers' identification with the organisation and a desire to advance in the organisational hierarchy. These norms imply a collectivist attitude. The distinction between researchers with individualist and those with collectivist identification is significant in terms of management of research as well as in terms of cross-institutional or cross-sectoral research cooperation. However, the two norm sets do not exclude each other but can co-exist at the same time[9].

According to Hagstrom (1965) there are some central values of science and there is a coherent scientific community. However, norms are dynamic and flexible and can be interpreted in different ways that are dependent on the context. Contextualisation is of importance in the debate of scientific norms. The scientific community is characterised mainly by differentiation, as recent research reveals. For that reason the debate on scientific norms and values has to take into account several other factors too: the differentiation among research institutions and research environments, the differentiation of research fields on the basic-applied and on the soft-hard continuum, differentiation in specialisations, national research traditions, communication patterns and networking, and the interaction with other agents in society (Becher 1989, Ernø-Kjølhede 2000, Kalpazidou Schmidt 1996 & 2002).

[9] A description of the different norm sets for career paths can be found in Ernø-Kjølhede 2000.

Another way to perceive the norm debate is that of focusing on the institutional setting and on the perspective of the Mode 1 versus Mode 2 discussion. In Mitroff´s terms, Mode 1 addresses "well-defined" problems and disciplinary university research while Mode 2 is trans-disciplinary in its character and research is carried out in the context of application.

Norms, counter-norms, values and attitudes build the framework for research cultures and traditions and influence the relations among researchers, between researchers and policymakers, researchers and other external interest and agents[10]. This implies the impact that norm sets have on cognitive processes. Norms, counter-norms, values and attitudes set the framework for what is legitimate to focus on with respect to research subjects and activities. In this sense the cultural setting and research traditions are considerable influences and control mechanisms, but not the only ones, as studies of research environments reveal (Graversen et al. 2002, Kalpazidou Schmidt 1996).

Mechanisms such as dialogue and communication, market, democracy and bureaucracy are other important control settings. *Dialogue and communication* (both internal in the institution and external in the form of networks) as control mechanisms in science shape research cultures and influence the development of science. Researchers thus have the possibility to build theory-based networks, method-based and/or subject-based networks. They also have the possibility to build interest-based networks (an example is cooperation with industry). Research networks are usually overlapping each other, and are of vital interest for the creation of multi-disciplinary and innovative science. Absence of networking on the other side may isolate researchers and research environments and even impede the development of whole fields of science (Law 1973, Barnes & Edge 1982, Foss Hansen 1988).

Market as a control mechanism in science is based on the demand and supply principle and the exchange of results or credits. Within this market, the scientists exchange their results for credit, recognition and grants. Markets can be described upon different dimensions. There are economic markets providing resources and funding (where research councils and industry operate) and non-economic markets (markets for research subjects). Researchers are actors in several interrelated markets such as the professional market (competition among professors, researchers), the academic market for credits and recognition and the market for grants, the publication and the teaching market (Hagstrom 1965, Bourdieu 1975, Latour & Woolgar 1979).

[10] Compare with Benner & Sandström 2000.

The classic academic control mechanism is *democracy* i.e. research autonomy in relation to external influences as well as research freedom that scientists have in their activities. The most important instruments for control are the internal democratic structure of research institutions, the autonomy of institutions and the traditions for research autonomy. This mechanism refers to a bottom-up influence structure (see Polanyi 1962, Price 1963). As previously discussed, there is a tension though between the classic academic control mechanism and strong demands for more societal control. Studies show that researchers have extended autonomy during the research process, but the degree of influence decreases when it comes to choosing the research subject. In addition, the degree of influence is higher among members of the academic elite (Graversen et al. 2002, Kalpazidou Schmidt 1996, Kalpazidou Schmidt et al. 2003).

Bureaucracy as a mechanism of control refers to internal and external influences. Bureaucracy as mechanism of control exercised internally from the hierarchy of authority, the elite structure and through the reward and resource distribution system is based on the classical control concept (Cole & Cole 1973, Broad & Wade 1982). Bureaucracy exercised from external influences such as research policy has often direct impact on the organisation of research activities and consequently on the whole framework of research.

There are on the other hand different theories, the so-called externalist theories that perceive development of research within a context and focus on the research-society relationship. *Galtung's theory* on the relation between research and society sees research as a reflection of society. Galtung's theory perceives the academic society as a society based on a structure of hierarchy where the scientific elite controls the development of research (Galtung 1981).

The theory of finalization is based on Kuhn's theory on the development of science. The theory was developed at Max Planck Institute in Starnberg and has a more differentiated approach to the external influence on research, compared to Galtung´s theory. The theory of finalization perceives disciplines as developed through norms and dialogue in three phases: a) an exploratory phase characterized by disagreement about theory, b) a paradigmatic phase characterized by internal theory development and c) a post-paradigmatic phase characterized by finalization and application of theory. According to the theory research is more sensitive and less resistant to external control in the exploratory phase. Research is though less resistant to external influences especially in the post-paradigmatic phase where new networks and communities are required and created in partnership with scientists, politicians and citizens. In the paradigmatic phase on the other side the most appropriate organisational setting is autonomous self-administration of institutions.

Other theories have quite different viewpoints on research. *Knorr-Cetina's theory on transepistemic connection of research* regards research development as depending on a combination of processes of dialogue within networks and, though to a minor extent, on market mechanisms. Processes are complex and indirect, and researchers are not always aware of the background for these. Transepistemic interactions often remain implicit and unclear (Knorr-Cetina 1981 & 1983).

Whitley's differentiated externalism perceives disciplines as organized differently and influenced by society in several ways. The degree of external influence is different as well. The influence depends on the one hand on the degree of interdependency between the researchers in a discipline or field, and on the other hand on the extent that the task is clear and readily definable when choosing research objects and methods. There are disciplines and fields where the external influence is of major significance for development and others where it is not (Whitley 1984).

There are other theories that take more descriptive starting points. These perceive research units as institutional organizations that can be changed with organizational means. Others again stress the importance of introducing *"management science" and "dynamic planning"* to research units as in any other institutional organization (MacCorkle & Archibald 1982).

The above-presented theories within externalism can be divided in two main categories namely social externalism and cognitive externalism. According to social externalism the influence of external factors is limited to non-cognitive processes while cognitive externalism (the theory of finalization, Knorr-Cetina´s theory) perceives the influence of external factors as reaching to the core of knowledge and influencing not only research production and outcome, but even the process of choosing research field. Cognitive externalism perceives knowledge as a relative feature.

Luhmann introduced the concept of autopoiesis in social theory perceiving science as an operationally closed and self-referential sub-system. Such systems are self-referential formations i.e. they are able to self-recur and self-generate due to the fact that they themselves produce the elements of which they consist. These elements are (in the case of functionally differentiated sub-systems as science is within society) communications that they produce and which in turn maintain them. Consequently science as an autopoietic system has its own medium (the truth) and medium code that guarantees its operation as such. Sub-systems are differentiated within society, not from society. Autopoietic sub-systems can thus be functional for

society in an effective way. Their autopoiesis guarantees that they can serve society efficiently[11].

According to Kalpazidou Schmidt (1996), there are two fundamental modes of organising research i.e. the urban and the rural. Urban and rural modes constitute two poles on a continuum where the research units can be placed dependent on their characteristics. Research units have though characteristics of both urban and rural modes. The question is therefore which is the most dominant. Urban researchers work in teams, usually in narrower and specialised fields. Research and its communication is highly organised and the publication form is mainly as articles in journals. Rural researchers work in broader fields (often with basic research), where research is in general not organised in teams, external communication not regular and the publication is in book form. The mode of organising research varies according to the field and discipline and has implications for the knowledge production as well as for the interaction with the surrounding society[12]. Recent research on innovative and dynamic research environments in Denmark demonstrates that such environments are mainly urban in their character and mode of organising research activities[13].

In Denmark, there are in general increased societal expectations with respect to public science contribution to RTD and Innovation in the country. Moreover, there is a long tradition of non-formal, individual-based industry-science interaction. However, the debate on this issue is intensive and there has been criticism from some researchers that universities and other public research institutions do not satisfactorily reward or motivate researchers for a more forceful orientation towards cooperation with the enterprise sector. Appointments and promotions are based mainly on publications and reflect traditional academic values.

This is also a part of the criticism coming from the industry side on a lack of motivation among university researchers for cooperation, due to the existing appointment system at universities. On the other hand, critics of a complete reorganisation of the public research system to meet industry demands may question the willingness and ability of industry – not least in small- and medium-sized companies – to make their internal adjustments in order to benefit from changes in public sector research systems. Despite such arguments not many question the societal necessity to adjust framework conditions in order to intensify the interaction.

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[11] Luhmann´s theory on science has though been criticized for describing the ideology of science (see Mayntz 1988; Münch 1994 & 1995).

[12] See also Becher´s discussion of dichotomies within scientific disciplines (Becher 1989).

[13] For a more comprehensive presentation of dynamic and innovative research environments see Graversen et al. 2002, Kalpazidou Schmidt 2002 and Kalpazidou Schmidt et al. 2003.

6.1. Commercialisation of Knowledge and Cognitive Impacts on Academia

Cognitive transformation is a precondition for the above-described developments at universities. However, many scientists perceive the emergence of entrepreneurial research as an anomaly. Utilisation of scientific outcome is though not a new phenomenon but was available to scientists long before, and the implications of their findings - for example in medicine - was significant. Others perceive the emergence of entrepreneurial research as a result of academic scientists becoming more aware of the prospects for profit that their research provides. This prospect was in the beginning built-in only in a limited number of research fields (as was the case for founders of biotechnology firms in the 1970s and 1980s). But recent developments demonstrate that such a cognitive transformation emerges in more and more fields, building trans-disciplinary fields.

Europe, compared to the US, has not been efficient in linking science and industry. Fragmentation is one important feature of European research. The gap between high scientific performance and industrial competitiveness in Europe has been called the “European paradox” (Papon 2000). Consequently, the question raised is why science (at universities and other public sector research institutions) failed to make contributions to the knowledge that advanced industrial economies were dependent on; and why enterprises lack the ability and/or capacities to efficiently use the knowledge produced in these institutions. Recent policy initiatives in relation to the 6th European Framework Programme address the issue.

But how can public research contribute to socio-economic development? According to Pavitt (2000), research contributes to economic development through different channels and varied forms and degrees of academic involvement:

- Enterprises receive inputs from public science in the form of human resources. Mobility between public science and enterprise (and vice versa, i.e. tailored training courses offered by universities and other public institutions) may contribute to the dissemination of both coded and tacit knowledge.
- Dissemination of knowledge in the form of publications, in conferences and through patents is the stock of knowledge that is available to the public and thus also to industry. Utilisation of this requires though adoption and absorptive capacities. But modern science is complex and usually very specialized which makes it hard to use, if these capacities do not exist. This is often the case for small- and medium-sized firms.
- Co-operative R&D activities of varied types between public research and enterprises are increasing. One form of activity might be that the product originates in the university but further development of it is undertaken by an enterprise. Another form of activity might be that the product originates

outside the university and academic knowledge is utilised to further develop the product.
- The establishment of technology-based enterprises by researchers or graduates from public institutions - the so-called start-ups or spin-offs - are important instruments for transferring new knowledge and technology to industry.

The engagement required of public research institutions in commercialisation of research varies in intensity and is related to selection of the above-mentioned mechanisms. Different mechanisms require different levels of engagement by enterprises, including the involvement of these in the process of selection of research subject.

The interaction between theory and application, academia and enterprise, individual and group research has nowadays developed into an acknowledged academic practice. In addition, the dualistic approach of basic versus applied research, publications versus patents and the development of theory in opposition to technological innovation is no longer valid in a growing number of research fields. Recent theoretical and methodological developments in some scientific fields have taken place simultaneously with, for example, superconductivity and genetic engineering and are questioning the linear model of the flow of knowledge from basic to applied research to development and industrial innovation. The traditional academic perception that knowledge is synonymous with development of theory is questioned (Gibbons et al. 1994).

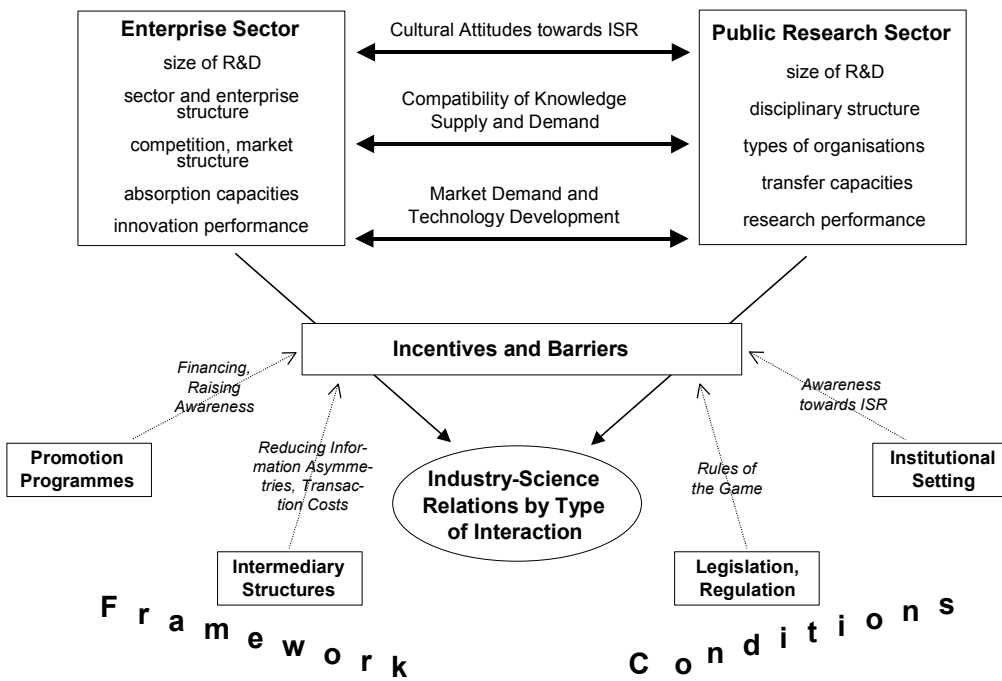
As the transition to increased entrepreneurialism at universities and other public research institutions takes place, in some institutions with modest pace though, the ability to obtain funding and gain societal recognition becomes an important skill for permanent appointments in laboratories, which often operate with high levels of external funding. This is of course not the tendency at universities in general.

Benner & Sandström (2000) argue that the institutional regulation of academic research influences the way norms in the academic system are constituted via research funding (cf. Nowotny 2000). The authors argue: “funding is a key mechanism of change in the norm system since its reward structure influences the performance and evaluation of research”. In an empirical study based on how public funding of technical research is in Sweden, compared with other countries, Benner & Sandström demonstrate that the structure of research funding has been changed in all countries included in their study. These changes had the effect of emphasizing commercialism and societal relevance of supported research. The researchers conclude: “the forces of change and continuity are engaged in a process of negotiation about the normative regulation of academic research”.

7. Framework Conditions in the Enterprise-Public Science Relationship

Three groups of variables are of importance for the industry - science relationship in a national context. The *first* group is, the characteristics of the main market actors (enterprises, universities and public research institutions), that represent demand and supply on the national market for knowledge, and which provide incentives and set obstacles for the relationship. The *second* group is, framework conditions such as infrastructures, legislation and regulations and institutional settings, which may stimulate or impede the relationship. The *final* group is, performance indicators that measure the extent of the interaction between science and industry in different fields of technology, as these are presented in figure 5 (Polt et al. 2001).

Figure 5. A Conceptual Model for Analysing Industry-Science Relations



Source: *Benchmarking Industry-Science Relations - The Role of Framework Conditions*, Final Report, European Commission, Enterprise DG and Federal Ministry of Economy and Labour, Austria (Polt et al. 2001).

The structure and performance of enterprises in an economy determines the demand for industry and science relations. This implies that the composition of the sector (size of R&D in the country), enterprise structures (relevance of large and multinational firms versus small- and medium-sized firms, relevance of foreign owned firms) market structures (degree of competition, level and quality of demand), absorption capacities (skills, innovation management capabilities) and innovation performance are important for the demand and accordingly also for the extent of the enterprise - public research relationship.

On the other hand, the public research sector has until recently been the main knowledge supplier and transmitter of capacities. Significant components here are the disciplinary structure, types of research organisations (universities, polytechnics etc.), transfer capacities influencing research orientation and mission (short-term applied research, long-term basic research, oriented basic research etc.), funding structure, personnel structure and reward systems, qualifications and capabilities, and research performance (Polt et al. 2001).

The level of the enterprise-public research relationship is strongly influenced by the extent to which demands for knowledge interaction and absorption capacities in the enterprise sector meets knowledge supply and transfer capacities in public research. Market demand and technology development trends are another factor of significance as these signify large information sources and competitive forces for enterprises to consider.

A fourth important feature encloses the cultural/social attitudes and perceptions of the role of research in society in general. The attitudes, especially within the enterprise sector, on the extent to which public research should be oriented towards the needs of enterprises are influencing to a high degree the relationship.

There are, within a certain national context, general framework conditions and publicly designed framework conditions (such as science policy) that attempt to minimise the barriers to knowledge interaction and to stimulate the relationship through different incentives. According to Polt et al. (2001) such framework conditions could be:

- *Legislation and regulation* may operate as an incentive stimulating the interaction or may impede this through laws for taxation of contract research and/or laws that complicate mobility.

- *Public promotion programmes* that provide financial resources to stimulate the interaction between enterprises and public research and thus compensate for transaction costs, spillovers, uncertainty of R&D results

as well as stimulating risk-averse capital markets. Public promotion programmes attempt furthermore to increase public awareness towards the interaction and even try to change attitudes and behaviours that are not positive.

- *Intermediary structures* are framework conditions that may directly be planned by science policy and cover both physical and immaterial infrastructure such as technology centres, incubators, consulting networks, information networks and databases.

- *Institutional settings* in higher education institutions and public sector research institutions determine the incentives or the barriers for researchers in public institutions to engage in the interaction enterprise-science. Institutional settings comprise evaluation criteria and procedures, individual reward, funding and schemes for R&D, institutional assignments and organisational cultures, strategic planning, recruitment policy etc.

Results from empirical studies reveal that there is a variety of types of knowledge interaction and exchange in national innovation systems. In addition, the studies show that there are differences in how effective the channels for exchanging a certain type of knowledge are (Foray 1994 &1997, Smith 1995). The significance of these channels depends on the type of activity, the type of knowledge required, and absorption and transfer capacities in both enterprises and public science.

Schartinger et al. (2001) argue that there are different types of knowledge interaction between enterprises and science that are based on both formal and informal/personal interaction, and that allow for transfer of tacit knowledge as well (which is regarded as a success factor in learning and innovation context). The interaction could be in form of:

- Collaborative research, that includes carrying out research projects in cooperation between researchers from enterprises and science.

- Contract (commissioned) research and technology consulting, i.e. placing of R&D contracts by enterprises in science institutions and use of technology advice.

- Personnel mobility. Temporary or permanent exchange of researchers between enterprises and scientific institutions.

- Co-operation in graduate education such as short-term practical studies in enterprises or joint supervision of these.

- Vocational training for employees that gives the opportunity for further education for the staff of enterprises in research and innovation related themes.

- Use of intellectual property rights by science as a tool for indicating technological competence as well as a basis for licensing technologies to firms and receiving royalties.

- Start-ups of technology oriented enterprises by researchers in science i.e. transfer of new results into commercial value by creating new firms.

- Informal contacts and enterprise-science networks on a personal or organisational basis, including information exchange and informal consulting, funding of professorships by industry, memberships in advisory boards etc.

- Employment of graduates in enterprises and transformation of knowledge from universities to enterprises, knowledge acquired through journals and scientific papers, joint scientific publications and lectures by employees of enterprises at public research institutions.

Others describe similar mechanisms influencing the interaction between enterprise and science (direct and indirect) referring to traditional mechanisms such as publishing and teaching. These researchers emphasise the role of various types of networks, meeting places and markets for the sharing of knowledge on the one hand and for the development of products and firms by researchers on the other[14]. Mechanisms are:

- Scientific publications that expand the technological prospect of firms.
- Supply of engineers and natural scientists.
- Supply of PhDs with essential provision of background knowledge, skills and personal networks.
- Participation in common informal networks, joint R&D projects, research funding and contract research with a sharing of explicit and tacit knowledge (gained through research and membership of national and international networks).

[14] See Meyer-Krahmer & Schmoch 1998, Pavitt 1998, Salter & Martin 2001.

- Linking national enterprises to international networks and providing access to explicit and tacit knowledge from a wider range of sources.
- Development of instruments and engineering design tools.
- Spinning off technology-based firms.

Some researchers[15] divide mechanisms (based on how important they are) into primary, secondary and tertiary mechanisms. The primary mechanism is research; the secondary is teaching at PhD and undergraduate level, while the tertiary refers to the remaining mechanisms. However, it is through the combination of all these mechanisms that academic research increases the rate of return of private and more applied R&D.

It is though mainly through high quality capabilities in research that scientists are able to provide significant contributions to enterprises. Generation of high quality capabilities is essential, as is the pace and strength by which universities and other public research institutions explore new fields. Generation of capabilities in science and utilisation of such capabilities in industry should therefore be developed, not only in terms of volume but also in terms of variety.

According to Loasby (1998): “Capabilities are the least definable kinds of productive resources. They are in large measure of a by-product of past activities, but what matters at any point in time is the range of future activities, which they make possible. What gives this question its salience is the possibility of shaping capabilities and especially of configuring clusters of capabilities, in an attempt to make some preparation for future events, which, though not predictable, may… be imagined”.

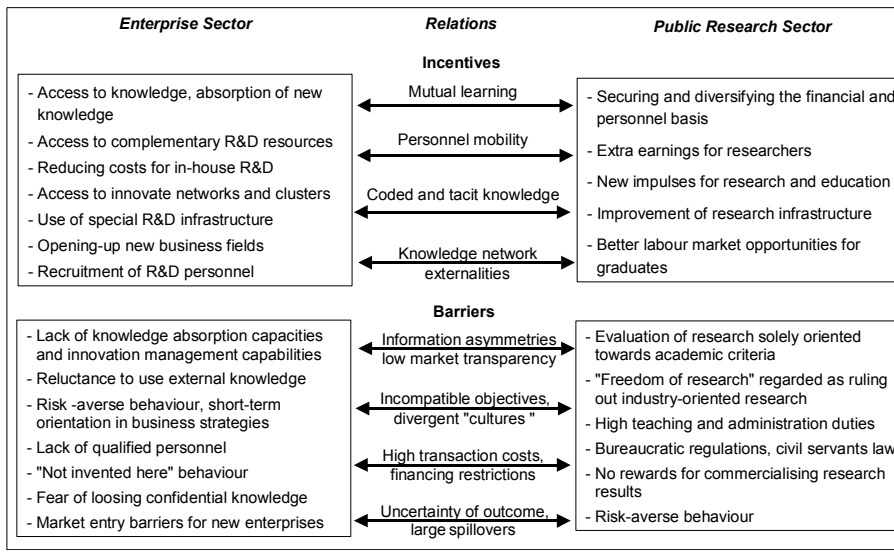
One of many mechanisms through which the benefits of the formation of capabilities are obtained is through technology-based start-ups. Studies show that existing companies and universities are the two main sources of new technology-based firms[16]. In a study of new technology based firms in Western Sweden (Lindholm Dahlstrand 1999), it was demonstrated that only a tenth of the firms were direct spin-offs from Chalmers Institute of Technology, the main Polytechnic Institute in the region. Another 21 per cent were indirect university spin-offs e.g. they were based on university research but were not established until the founders had achieved additional knowledge in a private company. Hence there was (for about one third of the technology-based start-ups) a clear relation between university research and private companies formation.

[15] See Lindholm Dahlstrand & Jacobsson 2002.
[16] See Keeble & Oakey 1997, Lindholm Dahlstrand 1997.

7.1. Incentives and Barriers to Interaction Research-Enterprise in the Literature of Science

Establishing an intensive interaction between universities and other public research institutions requires matching of knowledge supply and demand within a context, regional, national or European. The intensity and extent to which this interaction is functioning depends on incentive structures, but also on different obstacles that impede the interaction. Incentives and barriers and how these work within a certain economic system and the way these influence the attitudes, decisions and behaviour of RTDI stakeholders have recently been in focus at the European level. Polt et al. (2001) have identified some major incentives for and barriers to, industry-science relations in the private and the public sector, and in the relationship between the two sectors (figure 6).

Figure 6. Incentives for and Barriers to Industry – Science Relations



Source: *Benchmarking Industry-Science Relations - The Role of Framework Conditions*, Final Report, European Commission.

According to the survey, the main incentive for universities to establish a relationship to industry is the income for public research institutions coming from research collaboration with enterprises. Enterprises on the other side gain access to knowledge that may operate as a competitive advantage. Other incentives are

recognized in the area of education and R&D personnel recruitment, networking and mutual learning.

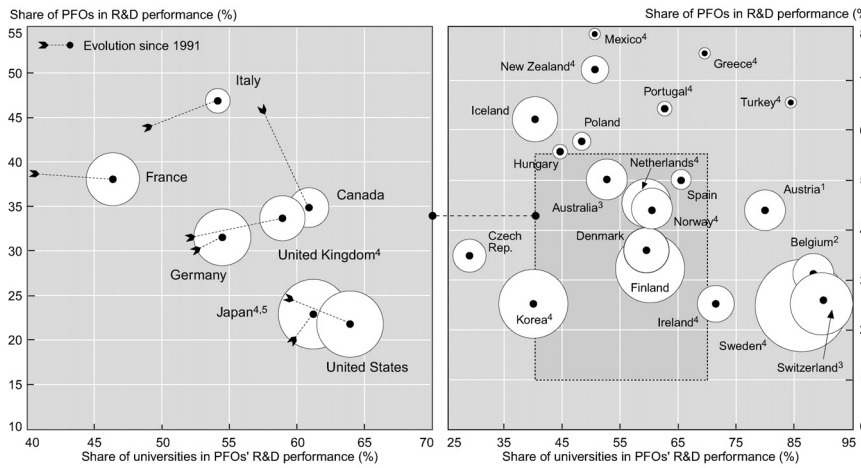
The barriers to the relationship between private-public depend on certain behaviour of the market actors (such as risk-averse behaviour, idiosyncratic behaviour, existing innovation management capabilities), market inefficiencies (lack of qualified staff and/or lack of financial resources), market failures (lack of transparency, information asymmetries, transaction costs, spillovers, uncertainty etc.). Other barriers may be incentive structures that are not favourable for the stimulation of industry-science relationship. Such barriers can be peer review evaluations that use solely academic criteria and do not take into consideration the societal relevance of research. Short-term orientation in enterprise strategies due to short-term oriented financial markets can be another non-favourable feature.

Incentives can be designed, and barriers can be influenced, by framework conditions that could be subject for public policy, in two ways. Firstly, as a direct result of certain framework conditions (discussed earlier) such as the legal framework, institutional settings in public research organisations, evaluation procedures applied, and/or regulation of labour and financial markets. Secondly, by public policy attempt to design a framework condition in a way that limits failures in the knowledge market diminishes the barriers and stimulates knowledge interaction between industry and science.

8. Enterprise-Science Relationship and Policy in Denmark

OECD studies (1999 & 2002) reveal that for the majority of the countries involved, there are only parts of the industry that have established cooperation with parts of the university system. This linkage is stronger in some countries than in others. Focusing on Denmark, the results show that the linkages between Danish industry and Danish universities were not as strong as in other OECD countries. Denmark held the 24th position among 28 countries (OECD 1999). This should be seen in the light of the total amount spent on publicly funded organisations (universities and other research organisations) in R&D performance. Denmark has, as figure 7 illustrates (adopted from OECD 2002), an average share of government R&D funding and performance. Figure 8 illustrates the share of business in the funding of research performed by government and university (OECD 2002).

Figure 7. Share of publicly funded organisations* (PFOs) in R&D performance, 1998, percentage.



Source: OECD (2002).
* Non-business R&D performers, Excluding non-profit private organisations.
Note: Circles are proportionate to countries' relative R&D intensity (total R&D expenditure as % of GDP), with a maximum for Sweden (3.8%) and a minimum for Mexico (0.3%)
1. 1993
2. 1995
3. 1996
4. 1997
5. Underestimated

Figure 8. Share of business in the funding of research performed by government and university. 1998 or latest year available, percentage. Source: OECD (2002).

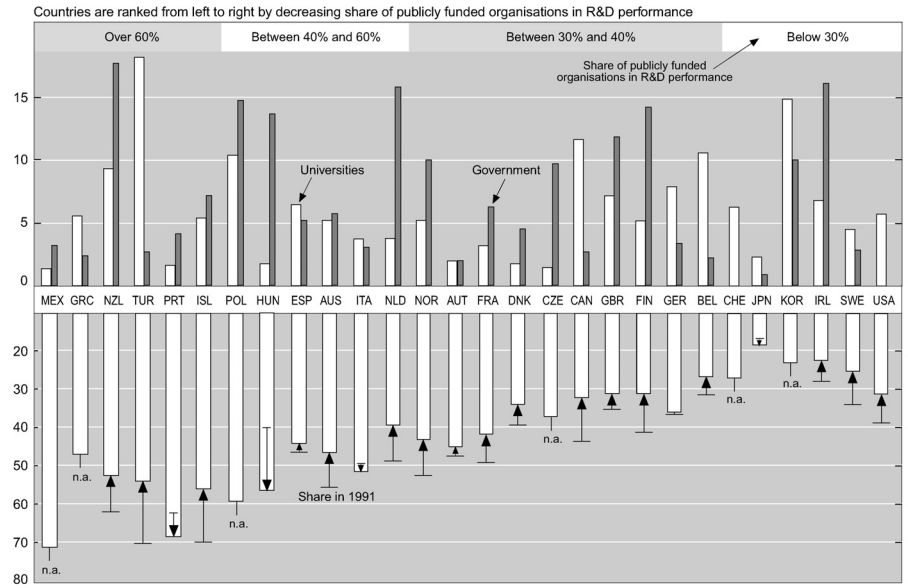


Figure 9. Share of government in total R&D funding. 1998 or latest year available, percentage. Source: OECD (2002).

According to OECD, the Danish university system is under-financed compared to other systems in OECD countries with equivalent income levels (OECD 2000). The Danish university system spends less than half of the resources per student compared to the US and 2/3 of the resources spent in Sweden. The share of government funds in total R&D funding in Denmark is though higher than in the countries mentioned above, as figure 9 illustrates.

Studying the Danish innovation system, Lundvall (2001) argues that there exists a specific Danish innovation system that is characterised by:

- An overrepresentation of small firms and few big companies (in an international perspective).
- A specialisation in products that have very low R&D content.
- Large number of small- and medium-sized companies, many with few or no capabilities with academic background.

However, Danish companies in all sectors are innovative with respect to products, processes and organisation (small countries paradox). According to Lundvall, innovations have their origin in new knowledge that is mainly produced abroad. Innovations in Denmark introduce products that are not new, seen in an international perspective. Competences are built up in firms based on broad experiences and through intensive co-operation with other firms, costumers and suppliers from both Denmark and abroad (Lundvall 2001).

This evidently does not describe the entire picture of the Danish innovation system. Recent studies on innovation among 600 Danish companies reveal that more than every third company is innovative[17]. This implies that the enterprises in focus have - during a three year period - developed a new product, significantly improved products and/or have radically reorganised one or several of their production processes.

Moreover, a comparison with other Nordic countries shows that, as far as innovation is concerned, Danish enterprises are on the same level with Swedish and Finish and over the level of Norwegian enterprises. Especially in high technology companies (medical industry included), but also within the knowledge intensive business sector, there is a considerable knowledge-based innovation system. Larger enterprises are more often innovative. Consequently, more than half of the enterprises with more than 50 employees are innovative. Among high-tech enterprises, and in the knowledge intensive business sector, the figures are remarkable high namely 9 of 10 are innovative.

The total amount of expenditures for innovation activities in Denmark was in the fiscal year 2000 approximately 43 billion DKK. The highest innovation intensity (assessed as innovation expenditure in relation to revenues) was found within the knowledge intensive business sector (15%) and among high-technology companies (9%), while the average intensity was approximately 6%[18].

In addition, studies show that it is first and foremost knowledge produced in the same company, in other companies and knowledge that enterprise employees get in connection with fair visits and from journals that have been utilised for innovation activities. Barely half of these companies have utilised the knowledge produced in public research institutions. However, 40% of the sample has an actual cooperation with others on innovation activities. Cooperation partners are to be found primarily among suppliers and costumers. Only one in four companies

[17] See The Danish Institute for Studies in Research and Reserach Policy (Graversen et al. 2003).

cooperate with universities and other public research institutes. Of the companies engaged in collaboration with public sector Danish partners dominate the picture. At the same time it is revealed that roughly half of the studied enterprises cooperate with foreign companies.

This is the context for understanding the Danish industry-science relationship. According to Lundvall (2001), the argument for not being able to establish a more organised and intensive relationship is the fact that the private sector has only modestly requested Danish produced scientific knowledge in the innovation process.

As it is hereby acknowledged, the interaction of industry with public research institutions is greater with some universities than others. In this respect even historical circumstances, such as the orientation of Polytechnics towards mainly academic science already from its foundation, could be a factor of significance for the establishment and further development of the relationship (Wagner 1998).

However, companies point out that social sciences and humanities are of high or very high significance for their enterprise[19] (see Appendix, table A.1). Focusing on differences between sectors, the same study concludes that the knowledge intensive business sector, which demonstrates the highest innovation intensity, and the finance sector point out that social sciences and the humanities are most significant for the development of their companies' knowledge reservoir.

Another feature of the Danish innovation system is the existence of consulting institutes (GTS-institutes, engineer firms and management firms) that function as bridge-builders between research and enterprises and operate on terms comparable to the private sector by use of income generating activities. The function of these institutes is to facilitate communication with the private sector and accordingly smooth the research process and the co-operation activities.

8.1. Public Policy Initiatives

In recent years a system of policy instruments has been introduced that guaranties public support to new co-operation initiatives (contracts, innovation environments and science parks, mobility programmes and exchange of researchers' programmes). This effort aims to overcome barriers that impede interaction between public research and enterprises.

[19] See the quantitative study of 600 companies undertaken by The Danish Institute for Studies in Research and Research Policy (Graversen et al. 2003).

New technology transfer structures and intellectual property policies have been introduced. Laws and policies governing the ownership of intellectual property policies at universities and other public research institutions are being scrutinized in Denmark, as in other OECD countries, with a view to encouraging ownership of inventions by the institution producing the research. A new legislation has been introduced to grant universities title to intellectual property that emerges as a result of public funding. The Act on inventions at Public Research Institutions (initiated in 2000) grants title to such institutions but allows the inventor right of first refusal. In addition a Consolidated Act on copyrights regulates ownership of literary and artistic works. Copyrights at public research institutions are governed by the same rules that govern copyright ownership in private enterprises. The government, as one of few among the OECD members, has also developed national guidelines related to conflicts of interests involving researchers and intellectual property activities.

Moreover Denmark, like other OECD countries, is experimenting with regional or sector-based technology transfer offices and the management of technology transfer activities for several public research institutions. Furthermore, legislation provides direct and indirect support, although on a time-limited basis, to help universities and other public research institutions cover costs associated with patenting and commercialising inventions. Indirect support in the form of decreased patent application expenditures for universities on the one hand and informational and awareness shaping measures on the other, have also been introduced.

Policies implemented by legislative or other means have proved effective in some OECD countries. One of the main impacts has been to raise awareness of and support technology transfer from public research institutions, particularly within the administration and among researchers and graduate students. Although identical approaches to technology transfer are not appropriate for all countries (due to differences between public research institutes and their role in national innovation systems) the impact of raised awareness among stakeholders is crucial. There is though some concern in the EU that different national legislations in member states may create obstacles to collaboration and may impede the highly required synergy effect in Europe (OECD 2002).

Before the introduction of the new law on intellectual property rights, only one of the twelve Danish universities had an office that dealt with technology transfer. This was the University of Aalborg that is technically oriented and active in mainly regional technology transfer supported by EC regional policy for “peripheral districts” in EU member states. In the late 1980s, other universities and a few university hospitals established embryonic industrial/external liaison offices. These mainly gave advice on applications for external funding. Some of the government

laboratories have had technology transfer offices functioning since the late 1950s. In the 1990s some university hospitals developed their liaison offices in the direction of technology transfer offices. However, this was not a general tendency in hospitals at the time (Milthers 2002).

In Danish universities and research laboratories, technology transfer offices in non-university based public research institutions are organised as a division of public research offices, but are not dedicated specifically to technology transfer. The question is hence, according to OECD (2002) whether there is an optimal institutional arrangement for technology transfer offices in the Danish innovation system.

Innovation policy in Denmark has primarily focused on improving conditions for enterprises with respect to better funding possibilities, public financial support for professional advice on management, recruitment, marketing, patenting etc. There is a programme though linking higher education and enterprises, the industrial PhD programme that provides enterprises with a possibility of refunding half of their expenditures for PhD students working on their thesis in a company (supervised by university professors). The new legislation, in force since summer 1999, gives priority to the role of public research institutions in the innovation system and the responsibilities in participating in this, in cooperation with enterprises (Milthers 2002).

The earlier mentioned studies on Danish innovation activities (Graversen et al. 2003) reveal the importance of research policy initiatives. In general, enterprises with intensive R&D activities estimate the significance of such initiatives as being high compared to other innovative enterprises with no R&D activity and to non-innovative enterprises. 10% of all enterprises indicate though that policies have no implications what so ever. The first group of enterprises (that has a high degree of cooperation with public research) has a very positive attitude in relation to public research in general and asks for increased resources to be given to public research. In addition, managers of innovative companies more often claim that changing of the organisation and management of universities (introduced recently by the government) could be an important research policy initiative (see table 1, adopted from Graversen et al. 2003).

Table 1. The significance of research policy initiatives. Percentage.

Share of managers estimating that a range of research policy initiatives have **a high or very high significance**			
Research policy implementation	R&D intensive companies	Other innovative companies (no R&D activities)	Non-innovative companies
Increased funding to public research			
Increased funding to basic research[1)]	46	42	45
Increased resources to PhD programmes[2)]	46	48	41
Increased funding to public research in general *)	**61**	**54**	**52**
Increased funding to fields/cooperation			
Increased funding to specific fields such as IT, gene-technology, energy supply and health	48	52	41
More funds to be distributed through the EU framework programme for research and technology	31	19	21
Increased funding to fields/cooperation in general[*)]	**59**	**52**	**44**
Increased funding to enterprises			
More funds to enterprises research	50	49	45
Changed management at universities			
Changed management stile at universities	42	50	24
Public research in general[*]			
Public research in general	59	44	44

Note:
*) Share of managers that in at least one of the policy initiatives posits high/very high significance.

A classification of the above-mentioned enterprises in sectors illustrates the variation in attitudes between the different sectors. Many of the enterprises, especially within the knowledge intensive business sector, underline the importance of more funding for public research. However, knowledge intensive companies are not in favour of a change in the university management system. This is the position though of the manufacturing industry which at the same time points out the importance of increased funding levels for enterprise research too[20].

For the majority of enterprises, public policy measures to support R&D activities have not had a strong impact on their prospects to RTDI activities (see table 2,

[20] See Appendix, figure A.2 (adopted from Graversen et al. 2003).

adopted from Graversen et al. 2003). Direct subsidies such as subventions and tax regulations are measures that managers (especially managers of R&D intensive companies but also those of other innovative firms with no R&D and of non-innovative companies) perceive as the most important. The next most important measure in this context is public funding to R&D activities at universities and research institutions and programmes to stimulate cooperation among companies and between companies and research institutions. It is mainly among the R&D intensive firms that this perception is common. However, non-innovative companies are also well represented here. This (together with the need that companies have for more information programmes and info-centers) implies a request for governmental assistance in order be able to start-up such activities.

Table 2. The significance of public supporting measures for enterprises possibilities to research and development. Percentage.

Share of enterprise managers estimating public supporting measures as being of **high or very high** significance			
Measure	R&D intensive companies	Other innovative companies (no R&D activity)	Non-innovative companies
Subsidies (tax regulations, subventions etc.)	21	18	14
Public funding to R&D at universities and research institutions	18	3	7
Programmes to stimulate R&D cooperation among companies or between companies and research institutions	16	3	12
Information programmes or programmes supporting technical development	13	3	8
Public purchase	10	9	10
Assistance in relation to patent application	7	0	4
Centres that gather technical information on innovation in other countries (Info-centres)	5	5	7

PART II

9. Main Results of the Empirical Study and Analysis

The results and analysis of the study presented here is based on in depth-interviews with managers of mainly prominent Danish private companies, though also with research leaders employed in private companies and leaders of non-profit organisations. The study focuses on selected enterprises with research activities and experiences from cooperation with public research.

The results reveal that there are different perceptions of the function and role of public research and universities, their management and leadership, objectives, strategies and instrumentation.

Managers describe obstacles to cooperation and offer suggestions to incentives and instruments that can be used to facilitate the relationship and intensify the exchange of knowledge. Research policy issues are consequently high on the agenda of managers.

In the following sector, the main results of the study and analysis are presented. The results, seen in the light of the literature of science and earlier research, give an extensive illustration of the subject in focus and are of relevance to the debate on research and science policy and efforts to achieve synergy between the three sectors in the innovation system i.e. public research, enterprises and government.

9.1. Perceptions of Public Research

In depth-interviews with enterprise managers reveal the following results with respect to perceptions of and attitudes on the enterprises-public science relationship:

- There are parts of some universities and public research institutes that have established an intensive interaction with some parts of the enterprise sector and industry.

- The greater experience companies have from research co-operation with universities and other public research institutions the more positive attitudes and perceptions are towards the interaction.

- The larger and (as the case is usually) more science- and research-based the company is (with a high proportion of research input out of the total input) the more interaction there is with universities and other public research institutions and the more positive attitudes and perceptions are on the interaction.

- Enterprises have difficulties in getting information on public research (information on know-who and know-how), especially small- and medium-sized companies.

- Enterprises that do not have any experience from interaction with universities and other public research institutes have difficulties in overcoming the barriers and in establishing a co-operation. This is profound especially among small and medium-sized enterprises that are not science-based and usually do not have any researchers (and in many cases not even academics) employed among their staff.

- In general, attitudes towards the enterprise-academia relationship vary and are dependent on characteristics of the market actors and the composition and structure of the enterprise sector on the one side and the public research sector on the other. In general, attitudes among small- and medium-sized enterprises are not particularly positive due to lack of compatibility of knowledge and knowledge asymmetries, lack of information on the existing knowledge reservoir and lack of absorption capacities.

- There are considerable differences in the perception of research objectives of public research institutions and universities on the one side (many engaged in long-term, basic research activities) and those of enterprises and industry on the other (have as a rule short to medium term objectives and are product oriented with the exception of larger science-based companies).

- The perception of strategies and instruments used in public research varies among the managers. Two main categories have been identified. The majority of managers posits that strategies and instrumentation in public research are highly different from those used by enterprises due to differentiation in objectives, demands on markets, market mechanisms and competition. Others find that contemporary universities adopt strategies and make use of similar instruments like enterprises in order to continue to attract funding in a highly competitive environment.

- Enterprises and science institutions use a variety of channels (some formal and/or mainly informal communication and contacts are used) in the interaction process.

9.2. Differentiation in Objectives, Strategies and Instrumentation between Public Research-Enterprises

According to enterprise managers, there are differences in research objectives of university and public research institutions and those of enterprises. The objectives of the former may be wider and abstract, less well defined, motivated primarily by scientific curiosity and epistemological interest (a bottom-up approach) and have often a long-term perspective. Moreover, objectives of public research may contain high risk while these of the enterprise sector are in general short-term (with the exception of larger companies that may have longer perspective in their planning), risk averse and maximum profit oriented.

The research agenda of companies is more focused and targeted and therefore in many cases easier to handle for managers. The decision-making is also different. Managers of private enterprises can rapidly and easier change orientation, focus and targets. According to some managers, as a consequence of this the instrumentation used in the private sector is different from that used in academia:

> *"The instrumentation is different. The (public research) agenda is broader and therefore you must use other instruments and this makes it harder. It is obvious that the instruments are used also in order to eliminate long decision processes… but it can never succeed in the same way. It can never compete with the private instrumentation because the agenda in the private sector is narrower".*

> *"In the private sector the objective is much clearer… Give us something we can use! This is partly the case also for public research but it is not the whole truth… it means that you have to control, at the same time, research that can produces immediate results and basic research that can be used to produce results in a long time perspective. These two things are much harder to control than private research… But the difference in instrumentation is getting smaller. This is an important issue even among private organisations… the assessment of basic research as if it was applied".*

> *"You have to be able to handle two different tools. An enterprise manager is his own in his small or larger firm while a research leader is not. The instruments are sharper in the enterprise sector. The feedback and evaluation is sharper".*

Other managers argue that the instrumentation used to achieve objectives is different between public research and industry. This is though not only characteristic for the difference between private and public but it could be the case

among enterprises too. The differentiation between private and public is rooted in the way assessments and evaluations of results and production is done in the two sectors.

> *"In the enterprise sector what count are assessments of implementations and the kind of products you send to the market. In the public research world, on the other side, it is a very indirect measurement that is used, typically citations etc… when you publish something… This is a significant difference. It implies two distinct ways of focusing on things. The consequence is that focus (in public research) is on selling the research results… overselling sometimes, this is my experience".*

Other managers argue that despite the dissimilarity in objectives between public and private, the instruments used to achieve these goals are similar. This is a result of the high competition that both universities and enterprises have to deal with in the new socio-economic environment.

> *"There is no difference as to tools used. If you are a leader you deal with people. It does not matter if it is the one or other place; it still is people that you deal with. I thought once that there were more soft values within the public… there are not. Public managers have a tendency, as I see it, to be harder some times. Danish managers in enterprises have adopted soft values, more than people assume in the public sector. The reality has changed… you cannot keep your employees otherwise".*

Some managers argue that there should not be any difference with respect to instrumentation utilised by enterprises and those utilised by public research managers because the requirements to both sectors nowadays are the same. However, the differentiation does exist.

> *"From a leadership perspective one should require the same qualifications. On the one side to coach the staff and on the other to formulate objectives and follow up… I do not think this has been the case in public research".*

Nevertheless, some managers perceive the broader scope of public research as the main objective of publicly funded scientific activity and as a complement to enterprise activities. Safeguarding public research (not only applied but also basic research) is an issue that concerns enterprise managers too.

> *"I do not think that it is a question of either private or public research because we have to secure a good basic research that industry does not*

control and this is the one that is going to be the basis for applied research. Let them (public researchers) therefore have the carrot and the possibility too, for example double the number of employees, if they do something important within informatics or biotechnology or whatever… but we have to first and foremost secure a good basic research within strategic important areas".

"Public research is, in a higher degree, oriented towards the world, the international arena and tries to find out what is going on and what is coming up. It may predict that in five years, there will be a need for this kind of knowledge and as a result, you may say, that it is creating basic research that can be used by enterprises in five or ten years from now".

In conclusion, it seems clear that there is a consensus among managers of enterprises on the existence of a distinction between the objectives of public research institutions and those of companies.

However, with respect to strategies and instruments used to achieve the objectives perceptions divide. There are several explanations for the differentiation in perceptions noticed in the interviews. This could depend on the type of company, the specific market, the research field, and the organisational and cultural setting of the sector.

9.3. Differentiation in Cultures and Norms

The scientific community is obviously not coherent. Concepts such as disciplines, fields and specialities are important in the norm and scientific culture discussion. This debate becomes more complex when the perspective becomes trans-disciplinary. Epistemological differences have implications for the way research is carried out and norms or counter-norms function in different contexts. Even informal structures of research environments – such as dialogue, communication, networking, internalised norms, values and traditions - influence the content and orientation of research, quality and international visibility and the productivity of units[21].

The present study shows significant barriers to cooperation rooted not in structural or organisational settings but in differentiation in cultures and norms that are characteristic for academia on the one side, and enterprises on the other. Many of the interviewed managers of enterprises emphasise though, that these differences

[21] See Becher 1988, Kalpazidou Schmidt 1996 & 2002, Sandström & Benner 2002.

are possible to overcome using simple instruments such as shorter visits to each other and temporary mobility.

> *"There are cultural barriers, not system barriers. These could be broken down by shorter postings".*

Prejudices based on lack of communication and dialogue are flourishing within both sectors. The more limited the knowledge of universities and public research institutions or scientific fields and specialisations is, the greater the misunderstanding and intolerance. The more limited the knowledge of the private sector is the greater is the misunderstanding among researchers.

> *"The mutual prejudices are getting worse. The longer you get from your own field the worse it is, and you cannot have a picture and understanding of it and you say `this is something awful`. But you have to reach them, not give up on them".*

Lack of communication that maintains divergence in norms and values between the public and private is another issue that managers point out:

> *"Researchers in enterprises are perceived as second class researchers… that they have a reliability problem in contrast to ´idealists´ at the universities…".*

The degree of interaction between public institutions and enterprises varies and depends on the discipline, the type of research, the scientific field as well as the university or public research institution in focus. According to the interviewed managers, *technical universities*, *business schools* and *applied oriented research institutions* involve more intensity in the interaction enterprise-public research.

> *"There is no doubt that the sector I am coming from is the most well-liked and considered to be the best among many enterprises. You have the whole apparatus within sector research, technical universities and X that are well known, also due to the results they produce. Then come the business schools as number two and then the traditional universities… and what is going on there? There is a lot of waste…"*

Even the Mertonian concept of "The Matthew effect" ("To those that have shall be given, and from those that have not shall be taken even that which they have"), is frequently present in the enterprise-public research relationship, linking the cultural and institutional setting to the function of funding and rewards. The use of solely

academic criteria in connection with advancement is a reward mechanism discussed by managers too.

> *"We have a close cooperation with technical universities, A and B. We talk to them when we need something. The technical universities are more willing to do this. They have already established a wide cooperation with enterprises and have the attitude that this is going to be used in a way, some time. Then on the other side, we have humanists and others and you think `do we really need this in the first place´?"*

> *"Researchers have been and still are hesitant to cooperate with enterprises because they want to publish the results. It is a requirement that you must publish in order to continue you career and advance. If you are assistant professor or PhD student you need to publish your results in some international journal".*

The majority of the enterprise managers participating in the study point out that the scientific community and the academic culture are not focused in their activity and usually lack strategic planning and dynamics. Hence, the results are not applicable for the companies in a short time perspective.

> *"There is no strategy, no strategic planning in research. No one says that `we think that in 10 years the world is going to be this way, which way may we go? What is on our focus´? So that we get some kind of a roadmap that shows us the direction… It does not necessarily need to be a strong decision control. Universities and research institutes need strategic planning so that companies can be able to say `this is not good, this is not something we would like to sponsor".*

Some managers claim that the general attitude among managers is that university researchers do not take into consideration the needs, possibilities and limitations of industry and enterprises. Instead their research focuses on fields that have only epistemological interest. Hence, this is primarily a consequence of a lack of communication and contacts, according to managers.

> *"If you for example take X and look into their research… I do not really understand whom they address their research to, except for themselves. This is my prejudice… I really have difficulties to see that research produced at X could benefit Danish industry."*

> *"Universities offer education but they are not always listening to enterprises requests".*

"Research institutions should respect the situation in which enterprises are in; but I do not think that they take the situation seriously".

Other managers claim that the main problem is the structure of the Danish market and its characteristics. The main obstacle is consequently lack of interest and awareness by companies on cooperation opportunities with public research and lack of attention to the potential that public research has. This is the case particularly among small- and medium sized firms. According to this viewpoint, problems are often a consequence of the structure of the Danish private sector.

"Many enterprises are based on craftsmanship, many of the great too, and they clearly have prejudice towards theoretical research. However, nowadays science is needed… problems can no longer be resolved from a craftsmanship perspective or -experience. This is the main difference from the old days"

A lack of understanding of research processes, practices and research cultures between the private sector and academia is another obstacle for more intensive cooperation.

"I think that in general there is a lack of understanding of each others conditions, even every day working conditions".

"The problem in public research is that it does not need to only focus on the bottom line; that is why it is more complicated to do research in universities than in enterprises. We always get to know that enterprises have difficulties in seeing what public research can be used for and that it does not take, in an appropriate degree, into consideration the needs of enterprises. And then you have the issue of securing the welfare state… It is a prejudice that public research is not focused enough, not effective enough".

"There is some prejudice on the pace and the way public research is done. The time from getting an idea to securing funding and producing a report is too long. Maybe you are not interested in making this result useful or available to industry. You are more interested in publishing in international journals instead".

The perceptions described above could have implications for science policy. It is obviously not uncomplicated to try to influence norms, values and traditions. A discussion of this issue follows in section 9.

9.4. Perceptions on the Public - Private Cooperation

Danish enterprises have confidence in the quality of public research produced in the country and make use of it, especially larger and R&D intensive companies as the interviews and tables A.3 and A.4[22] illustrate. Managers underline though that enterprises acquire knowledge and recruit expertise where they can find quality, and that cooperation is not based on national, regional or local criteria. This implies the confidence of managers in Danish public research. The closer the relation, the more positive is the perception of public research.

> *"Quality and not nationality is the most important criteria for cooperation".*
>
> *"Enterprises look for quality, that is why they also go abroad".*
>
> *"There is not an underlying strategy behind the choice, you go there where you can find the product".*

However, some managers find an advantage in cooperating with universities and other public research institutes that are located nearby.

> *"It is an advantage to be near. There is a tendency to work closely together when you are next to it. Personal contacts are important".*
>
> *"It is a myth that Danish firms go abroad looking for cooperation. They go abroad if it is lucrative, not as a principle".*

Others claim that legislations in other countries facilitate the interaction. In addition universities abroad with tradition in cooperation with enterprises, have different attitudes to cooperation and have developed mechanisms that smooth time-consuming processes.

> *"Universities abroad have a different viewpoint. We make deals in no time. In this respect Denmark is in the fifth division. I could deliberately move research projects out of the country because I do not want to struggle anymore".*

The central issue of whether enterprises are interested in, and pay enough attention to the potential of Danish public research is also in focus in the interviews with managers. The general perception is that for the large part of small- and medium-sized companies the knowledge reservoir of public research remains

[22] See Appendix (based on the quantitative study by Graversen et al. 2003).

unknown. There is though a differentiation among enterprises. Some sectors are more active in looking for public research to utilise.

> *"They do not pay enough attention within my sector. The dissemination and marketing of results are not good enough either".*

> *"There is not doubt that some sectors in traditional Danish firms are not aware of how much they can get out of cooperation with public research. It is primarily because they are small and have difficulties in penetrating the public sector and the academic world".*

The issue of lacking synergies between public and private was raised often in the interviews.

> *"We have too little synergy in many things nowadays. Things are as they used to be and we are not moving forward. We are incredibly lacking back in Denmark because we do not spend enough money on research, especially not on basic research".*

> *"It is the attitude that public research is not focused enough. It is not effective enough, maybe not effectively planned in the sense that one knows what is going on in the different fields – you have a researcher in this ivory tower and another in the other ivory tower and they maybe do the same thing…so why can't they get together and coordinate and have a better synergy effect?"*

A variety of channels and formal and informal contacts are used in the interaction between the public and the private[23]. Managers emphasize though in the interviews the importance of face-to-face informal contacts for establishing cooperation.

> *"It is important to bring partners together. If they can't talk together, get to know each other and start discussions, nothing is going to happen. I do not think you can come a long way if you only produce reports together and meet at conferences. It has to be face-to-face communication on all levels.*

> *"Mobility and exchange in general is needed. You can break down prejudices this way; see that there are not so many barriers when you are in it. More mobility… people from public research to visit enterprises and*

[23] See Appendix, tables A.3, A.4, A.5, based on Graversen et al. 2003.

vice versa. I could imagine that people from industry go in the university and look at a certain field. All this in order to initiate closer relations".

There is though great uncertainty related to this approach if the framework for research activities does not sufficiently support informal contacts. The fact that the compatibility and the absorbability of knowledge among small- and medium-sized companies are limited, does not speak in favour of using only this approach without combining it with other initiatives.

9.5. Information on and Access to Public Research (know-who and know-how)

The interviews with managers highlight in general the high confidence in Danish public research. Enterprises (especially those with intensive research activities) put attention on the production of knowledge at universities and public research institutes, and make use of it. The results of the present study are also confirmed by other studies, as mentioned earlier.

However according to managers, there have been several obstacles regarding transfer and access to public research. Many of the small- and medium-sized enterprises have had great difficulties in finding their way in the public research arena. Problems have their origin in the composition and structure of the market sector on the one hand and the public research sector on the other. A key issue is the lack of compatibility of knowledge and absorption capabilities among small- and medium-sized companies.

"It is difficult for us to find out what is going on. Public research environments are like small islands that are difficult to have an overview on. The state should establish a website with an overview on all research in Denmark. There is no place where the information is gathered… The results are not being marketed well enough".

The Ministry of Research, Technology and Development has however, as a first step introduced a website with information on research activities, know-who and know-how in order to help solve these problems.
The more research-based an enterprise is the greater interest, the better information on research (not only Danish but also international), the better communication with university institutions and researchers, and the higher the degree of utilisation of public research results as well.

"I really think that in places where there is an actual cooperation, it is functioning very well. This means that there are no obstacles there…

People I know from the medicinal industry, to take an example, they think that it works extremely smoothly… What I am hearing from organisations in the agricultural area, they are very pleased with the (public) research in this area".

Public research initiatives should, according to managers, focus on small- and medium-sized enterprises that lack access to public research (for reasons that will be discussed in a following section).

9.6. Barriers for Intensive Cooperation between Private - Public Research

Different barriers that impede closer linkages between enterprises and public research institutions have been identified by the interviewed managers. These can be structural or contextual but also of institutional and/or of legislative and regulative character. Barriers can also be rooted in prejudice, misunderstanding and lack of interest for each other's point of departure, cultures and practices, norms and values.

The main barriers identified by the managers participating in the study are summarised as follows:

Structural and contextual barriers

- Difficulties to get information on public research and the existing knowledge reservoir.
- Difficulties in matching knowledge supply and demand.
- Information asymmetries (open public research versus closed private enterprise and low market transparency).
- Different, and in many cases incompatible, objectives.
- Uncertainty of outcome in public research – high-risk research/large spill-over.

Institutional settings

- Public domain mentality of universities (bureaucracy, "ivory tower", inefficient organisation and long-term perspective research).
- Bureaucracy and inflexibility of administrators and researchers.
- Poor marketing/technical/negotiation skills and marketing orientation of universities.
- Lack of resources devoted to research and technology transfer by universities.
- Universities are some times too aggressive in exercising intellectual property rights (especially in relation to publication).

Legislation, regulation and policy

- Lack of motivation and reward mechanisms for public researchers with respect to engagement with enterprises.
- Lack of capabilities at universities that enterprises could utilise.
- High transaction costs from enterprise to university – financing restrictions.

Differentiation in cultures, norms and values

- Divergent cultures and objectives.
- Universities are closed systems that are not interested in cooperation.
- Lack of understanding regarding corporation, business and commercialisation of research results at universities.
- University researchers do not understand corporatism and are not interested in understanding it.
- Universities are not interested in business and commercialisation of research results.
- Universities are bureaucratic and based on inefficient, not flexible organisation that could cooperate with enterprises.
- Only some fields (limited in numbers) are of interest for the enterprises.
- The perception of time and pace in the activities is different in the two cultures (public research is slow and time consuming).
- Public researchers have unrealistic expectations regarding the value of their research.
- University researchers are driven by curiosity and interest, while the bottom line in the enterprise culture is revenue.

In an international perspective, these barriers are not only characteristics of the Danish entrepreneurial scene but are common features in other countries too[24]. As regards the situation in Denmark in particular the survey reveals five main features that can be subject to specific research policy initiatives. These features are:

- Lack of information on public research that enterprises can utilise.

- Lack of capabilities that enterprises can utilise.

- Lack of communication (and informal contacts) that can improve understanding of the cultural and normative settings.

[24] Compare to Georghiou 2001, Polt et al. 2001 and OECD 2002.

- Lack of incentive structures and institutional settings in public science that can motivate researchers and facilitate interaction with enterprises.

- Lack of possibilities for absorbability of research by small- and medium-sized companies with little or no academic capabilities. This is a feature that characterises the Danish private sector in general.

These are the main barriers to a more intensive interaction between enterprise and public research in the Danish framework. Public promotion programmes such as the PhD and research exchange programmes introduced by the government, and intermediary structures, such as the newly launched database and information network devoted to fostering the industry-academia relationship, provide resources and physical and immaterial infrastructure in order to facilitate the interaction. Moreover, programmes are introduced (such as a new think-tank on public awareness) to raise awareness on the role of research in society (which already is high in Denmark) and try to change behaviour and attitudes towards science.

The issue of obstacles to cooperation and innovation activities was raised in the quantitative study, too[25]. A high percentage of non-innovative companies point out that at least one of three suggested barriers are of great importance for cooperation prospects. *Diverging knowledge interests and competences* are pointed out to be the main barriers for cooperation prospects, from many innovative firms that have not established cooperation. The obstacle, *lacking knowledge on public research environments,* is more significant for non-cooperating enterprises in all categories but mainly in non-innovative and other innovative firms (with no R&D activity), as table 3 illustrates.

[25] See Graversen et al. 2003.

Table 3. The significance of barriers in relation to cooperation in the innovation process. Percentage.

Share of managers estimating the significance of barriers to cooperation as being **high or very high**					
Barriers to cooperation	R&D intensive companies		Other innovative companies		Non-innovative companies
	Have a coope-ration	Do not have any coope-ration	Have a coope-ration	Do not have any coope-ration	Do not have any cooperation
Reluctance to distribute knowledge and share competence with cooperation partners	27	31	26	32	25
Lack of knowledge of other companies as partners	12	18	11	44	25
Lack of knowledge of public R&D environments as partners	11	18	11	22	30
At least one of the above mentioned options	**38**	**54**	**39**	**78**	**49**

The results presented in table 3 confirm statements of managers in the interviews. The barriers pointed out (especially by companies that have not established any cooperation and lack knowledge on public R&D environments) should be addressed when forming instruments such as the matching of enterprises with public research institutions. In addition, a more effective dissemination of results could give increased information to companies on possibilities to acquire information from the existing public knowledge reservoir.

In the quantitative study mentioned earlier, managers were asked to appraise the significance of several barriers to increased innovation or to starting up of innovation activities, which is illustrated by table 4 (Graversen et al. 2003).

Table 4. The significance of barriers for increased innovation or starting up of innovation activities. Percentage.

Barriers	Share of managers appraising that a barrier have **high or very high** significance		
	R&D intensive companies	Other innovative companies	Non-innovative companies
Lack of resources			
Lack of financial resources	45	45	37
Lack of human resources	57	48	43
Cooperation and contacts			
Missing other companies as cooperation partners	13	22	25
Missing of contacts with public research and development environments	12	15	30
Market and competence barriers			
Focus is primarily on other competences than innovation	18	41	31
Market saturation	20	29	16
Tax and depreciation regulations			
Unsatisfactory tax regulations	25	26	26
Unsatisfactory depreciation allowances	23	29	27

According to managers, *lack of resources* is the most important barrier to more intensive innovation or to starting up of activities for non-innovative companies. *Lack of human resources* is in particular very important mainly among R&D intensive and other innovative companies. Moreover, lack of financial resources is a noticeable feature among small firms and especially among them that have competitors that are R&D intensive firms. A sector analysis shows that mainly knowledge intensive companies consider lack of financial resources an obstacle to innovation.

Confirming the results of the qualitative study presented here, table 4 illustrates that mainly non-innovative companies point out the *lack of contacts with public research and development environments* as barriers for starting up innovation activities. *Unsatisfactory tax- and depreciation regulations* are the next important barriers, namely for every fourth company. *Market and competence barriers* are other obstacles in this connection, according primarily to managers of other innovative (that lack R&D activities) and non-innovative companies.

This implies a need for policy initiatives to engage non-innovative enterprises in innovation. Lack of human resources is another issue to focus on. Higher education and research policy may focus on training and mobilising of the human resources needed in the private sector as well.

9.7. Suggestions for Improvements of the Relationship

The following are objects to focus on in order to improve relationships and co-operation between enterprises and public research institutions. According to managers participating in the study universities should:

- Educate their staff better in order to overcome informational and cultural barriers.
- Build more capabilities that enterprises can use.
- Devote more resources to research and technology transfer to industry.
- Develop a system providing easy access to their knowledge reservoir (access to know-how and know-who) and indicate how collaboration could be established.
- Develop systems, mechanisms and expertise to handle research and technology transfer.
- Develop more forceful market orientation and marketing skills.
- Put increased attention to fields of science of high economic importance.
- Develop a higher degree of strategic planning adjusting to the economic development in the country.
- Improve management and leadership of research.
- Increase networking between scientists and enterprises.
- Improve reward systems for research and technology transfer activities.
- Create greater motivation of public researchers to increased cooperation with enterprises.
- Be less forceful in exercising intellectual property rights.
- Be less forceful in exercising publication rights.
- Universities and enterprises should devote more efforts to develop mutual understanding and establish informal contacts.

Companies on the other hand (particularly the small- and medium-sized firms) should according to managers, upgrade their organisations and adjust production to demands of the new economic environment.

9.8. Incentives for more Effective Interaction

A central question for the actors in the innovation system is: What is there to gain? The answer could be that stimuli for enterprises and public research institutions to cooperation may be augmented with respect to:

- Knowledge on knowledge.
- Mutual learning (through teaching, training, conferences, workshops, visits).
- Access to knowledge (know-how and know-who) and technological problem-solving.
- Exchange of coded and tacit knowledge.
- Access to complementary RTDI resources (also co-financing/sponsoring of postgraduate and doctoral students).
- Establishment of intermediary structures such as centres, embedded laboratories, networks, companies designed for the purpose that can be of significance in a long term perspective.
- Access to specialised equipment.
- Personnel training and mobility (public researchers, PhDs and Masters, taking up employment within enterprises and industry researchers taking up employment in public institutions or establishing of joint laboratories).
- Establishment of knowledge networks (informal and formal) and clusters.
- Building capabilities.
- Elimination of competition and tensions (arising from universities commercial activities) between universities and industry.
- Limitation of the uncertainty in research processes and outcomes.
- Achievement of synergy effect.

Public policy can be a mediator in the process of establishing cross-sector linkages. Policy can set the legislative rules and institutional frameworks to provide incentives to public research institutions and researchers and promote cross-sector cooperation.

Important policy issues for the RTD and innovation system are:

- Matching supply and demand of scientific knowledge.
- Improving the responsiveness of public research to emerging needs of enterprises.
- Training and mobilising human resources.
- Promoting the participation of small- and medium-sized firms in the innovation process.

Science policy can use instruments such as funding mechanisms, evaluation of publicly funded research and benchmarking to achieve objectives of RTDI systems.

Some of the instruments already used in Denmark are *The Danish Industrial PhD programme* and *The Danish Investment Fund*[26]. The attitudes of 600 managers to these policy instruments expressed in terms of utility and/or aspiration to utilise them is illustrated by table 5 (Graversen et al. 2003).

Table 5. Companies use of or aspiration to make use of specific policy instruments. Percentage.

Policy instrument	R&D intensive companies		Other innovative companies (no R&D activity)		Non innovative companies	
	Have made use of	Wish to make use of	Have made use of	Wish to make use of	Have made use of	Wish to make use of
The Danish industrial PhD programme	22	17	0	19	1	7
The Danish Investment Fund	10	31	0	46	0	21

Only companies with R&D capacities have made use of the policy instruments in question. Other innovative firms (without R&D activity) expressed a wish to make use of the Danish Industrial PhD programme and, to a higher degree of the Danish Investment Fund. Furthermore, nearly half of the larger companies (with more than 250 employees) make use of the industrial PhD programme.

In addition, the importance of different public policy instruments for companies has been subject to investigation in the quantitative study[27]. Increased public funds to enterprise research and more funds to specific targeted areas such as IT, biotechnology, energy-supply and health are important public policy supporting measures as table 6 illustrates.

[26] The Danish Investment Fund is a state owned financial company, operating independently in the capital market. It facilitates the supply of venture capital in terms of start-up equity and high-risk loans. The fund invests in private venture funds specialising in specific industry sectors and in companies whose business ventures are innovative and have a high growth potential.

[27] See Graversen et al. 2003.

Table 6. The significance of different public policy supporting measures. Percentage.

Share of enterprise managers estimating some public policy measures as being of **high or very high** significance			
Public policy supporting measure	R&D intensive companies	Other innovative companies (none R&D activity)	Non innovative companies
More public funds to enterprise research	50	49	45
More funds to targeted areas such as IT, biotechnology, energy-supply and health	48	52	41
More funds to be distributed through the EU framework programmes for RTD	31	19	21

Managers perceive specific public policy incentives and supporting measures to encourage cooperation in the innovation process, such as *access to public research institutions knowledge and competence* being of great importance for their activities (see table 7, based on Graversen at al. 2003). This is the case particularly for companies that have established cooperation with public research institutions. The share of managers that posit that *achieving increased commercial success* due to cooperation with public institutions is of importance for their companies is high too. *Eliminate technical risks and uncertainties in research processes* are also perceived as an essential impact of their cooperation with public research.

This illustrates also the confidence that managers have in public research. It strengthens the results of the present study where the interviewed managers point out their confidence in public research on the one hand and the fact that the more contacts to public research the more positive are the attitudes and perceptions of the interaction.

Table 7. The significance of public policy incentives and supporting measures for cooperation in the innovation process. Categorisation in types of partnerships. Percentage.

Share of managers estimating incentives or supporting policy measures as being of **high or very high** significance

Incentives/supporting measures to encourage cooperation	Cooperation partners							
	Companies		Public Research institutions		EU-countries		Non EU-countries	
	Yes	No	Yes	No	Yes	No	Yes	No
Incitements								
Access to other companies knowledge and competence	62	51	66	52	62	51	67	52
Eliminate technical risks and uncertainties in research processes	45	47	47	46	45	47	50	44
To achieve increasing commercial success	57	53	59	52	55	54	61	52
Have someone to share the expenditure with	32	56	36	45	33	57	31	49
Increased opportunities for public funding, EU funding included	19	37	23	28	20	36	12	35
Supporting measures								
Information programmes or programmes supporting technical development	13	9	17	8	13	9	15	9
Programmes supporting cooperation on R&D; private-private or private-public	18	8	24	8	19	7	20	10
At least one of the above mentioned options	**84**	**80**	**91**	**78**	**83**	**80**	**86**	**80**

10. Implications of Scientific Cultures, Norms and Values for the Public Science – Enterprises Relationship

As the results of interviews with managers reveal, some researchers and research environments are open, cooperative and (to some extent) seem to have adopted norms and make use of practices from the private sector, while others are characterised by a more traditional academic culture.

As a consequence, one essential question is whether universities and public research institutes can remain closed to society in general or they (as some researchers argue) are already in a process of transformation as a result of the development that is changing knowledge production processes. Are theories on science, as they have been described by Merton (the ideal of science) or Luhmann (autopoietic social systems), an illustration of the real scientific world, or are other theories more accurate by describing the transformation processes as changing also scientific cultures and cognitive processes?

In 1985 Luhmann outlined the theory of autopoietic social systems referring to the ability of cells to self-recur and self-regenerate and inspired by the studies of Chilean biologists Maturana and Francisco on autopoiesis. Luhmann introduced the concept of autopoiesis in social theory considering society as an operationally closed and self-referential system. In modern society even functionally differentiated sub-systems have developed in the direction of autopoietic systems, according to this theory. Such systems are self-referential formations i.e. they are able to self-recur and self-generate due to the fact that they themselves produce the elements of which they consist. Sub-systems are differentiated within society, not from society. Autopoietic sub-systems can thus be functional for society in an effective way. Their autopoiesis guarantees that they can serve society efficiently.

Luhmann (1991), focusing on science, describes the function of it in terms of producing knowledge. Other sub-systems also have the same kind of function, but only science has this as its main task. Science, perceived as an autopoietic system, has its own specific medium and medium code. According to Luhmann, truth is science´s medium and the distinction between true and untrue is its medium code. The medium and medium code guarantee that science can operate according to its own principles i.e. autopoietically. Science decides how concepts like true and untrue are distributed into theories, statements and observations and is therefore normatively independent. However, normative autonomy does not mean independence in relation to the socio-economic and political environment. Luhmann claims though, that regarding theoretical and methodological issues but even regarding the evaluation of results, science functions in an autonomic and closed way (see also Sevänen 2001).

Luhmanns perception of science is, like Merton´s, a description of the ideology of science rather than science itself. It is evident that science does not use purely epistemological criteria, at least in the process of evaluating scientific outcome. Criteria such as utility, accountability, socially robust knowledge, applicability, societal relevance, etc., are generally accepted nowadays and used in highly complex socio-economic contexts.

Two other researchers, Mayntz (1988) and Münch (1994, 1995) suggested, in their discussion of the concept of autopoiesis in science, the use of autopoiesis as an analytical tool. According to Mayntz and Münch, functional sub-systems should be regarded as operationally closed formations, but only to a certain degree. This implies that sub-systems operate openly in some respects. According to Mayntz and Münch, autopoiesis characterises only some features of the sub-system science, while other features may connect them with other sub-systems. However, Luhmann opposes this definition and argues that a functional sub-system operates either autopoietically or not. In Luhmanns view, there is not a third option.

To maintain a sub-system (such as the scientific) is though to maintain and control its boundaries. However, the boundaries of science are no longer so clearly separable in emerging knowledge-based societies. Science is increasingly penetrated by society and vice versa. Society "speaks back" to science. This issue is, as discussed earlier in the report, in the focus of science theory and debated in connection with priorities of the European Unions 6th Framework Programme[28] and hence, subject to policymaking.

According to theories on the new production of knowledge, Mode 2 and triple helix literature, science is perceived in its socio-economic context, and knowledge is generated in the context of application. Society and users are becoming increasingly involved in the production of knowledge from the beginning of the process. In this perspective, societal accountability is a central feature.

Nation-states and national societies of todays - where individual societies are interdependent economically and politically and cannot develop as closed national systems - are not the same important agents in the knowledge production process either (Beck 1994, Giddens 1992). Sociologists argue that functional sub-systems have started to fuse to an increasing degree. Consequently clear boundaries between different sub-systems no longer exist. Functional sub-systems nowadays use media, codes and criteria that are used in other sub-systems as well (cf. Sevänen 2001).

[28] See The Danish Institute for Studies in Research and Research Policy 2001/8 (MUSCIPOLI Workshop One) & 2003/3 (MUSCIPOLI Workshop Three).

In line with these arguments, it is questionable whether concepts such as Luhmann´s autopoiesis give an adequate explanation of science as a functional, operationally closed, self-referential sub-system. The concept can however be used as an analytical instrument as it has been suggested by Mayntz and Münch. Autopoiesis in this perception characterises some features of the sub-system academia while other parts operate openly.

The results of the present qualitative study point in the same direction as conclusions and suggestions given by Mayntz and Münch[29]. From the interviews with enterprise managers, it has been concluded that features of the sub-system, universities and public research institutes operated quite openly (had intensive interaction with and were influenced by other sub-systems) while others were more closed and autopoietic in their organisation and function. It is obvious that the trend is moving in direction of a more open system with fewer clear boundaries.

The implications are that researchers and research environments, to a certain degree, adopt norms and practices from society that have traditionally characterised other systems such as the entrepreneurial, as the interviews with managers in the present study show.

These findings are supported by other recent studies. The point of attention for well-functioning research environments is hence strategic planning and definition of research objectives, organisation and management of research, coordination of activities and team working. The scientific elite that often comprise the leadership, ensure quality of research and assist younger researchers both in the socialisation process and in relation to the different markets that constitute the context for research, such as publication and funding markets. The organisation is characterised by an ability to adjust to external conditions and a sensibility towards changes in the surrounding society at the same time as it promotes the interests of the research group. Well-functioning environments are open to requests from society, including the private sector[30].

In conclusion, a part of academia is getting closer to the private sector, dialoguing with it and adopting some of the norms and practices that traditionally have been characteristic of entrepreneurialism.

The approach of the Mode 2 concept and the new production of knowledge, which has been introduced in relation to the constitution of science and research

[29] See Graversen et al. 2002 & 2003, Kalpazidou Schmidt 1996 & 2003.
[30] For a detailed discussion of well-functioning, and dynamic and innovative research environments (and what characterises these) see Kalpazidou Schmidt 1996, Graversen et al. 2002 and Kalpazidou Schmidt et al. 2003.

practices, emphasises a similar point of departure. Mode 2, as previously discussed, illustrates the growing contextualisation and socialisation of knowledge. The implications of the argumentation of the Mode 2 concept are that science and research can no longer be regarded as an autonomous space, demarcated from the rest of the society.

It is consequently questionable whether the Mertonian norms or the autopoietic perception of science can describe the multifaceted processes of today's science. Contextual factors are influencing processes, practices, norms and cultures in science.

10.1. Features of Scientific Knowledge Production

The results of the present study conclude that barriers to a more effective cooperation have organisational but also normative and epistemological components. Consequently, the discussion of obstacles to interaction between public research and enterprises, and the organisations of the two sectors, takes into account cognitive and normative issues as well.

Managers usually discuss the production of knowledge in public research institutions as basic versus strategic research. Irvine & Martin (1984) give a definition of basic research: "Basic research carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognised current or future practical problems".

Strategic research (that managers often referred to in the interviews) implies that considerations of socio-economic relevance are internalised in research processes. This is though not a new phenomenon. Already in the 1970s the Starnberg group, based on Kuhn´s theory, formulated the finalization thesis, which was also related to cognitive issues that influenced internalisation. However, there are some new elements to internalisation i.e. external social and institutional pressures for internalisation of scientific relevance. At the same time, an increasing receptiveness to external pressures is noticed among the researchers. These growing pressures that are external to science are new, but the mechanism of internalisation of external stimuli has always been there, ever since the beginning of scientific work (Rip 1999).

Benner & Sandström (2000), having as a point of departure the triple helix concept, show that funding and funding organisations create "organisational fields" that over time influence the norms and practices of researchers as well as the organisational structures of their institutions. According to Benner & Sandström (2000) the institutional settings of academic research influence the way norms in the

academic system are constituted. The normative processes refer to the norms and values that regulate conduct within organisations. The authors argue that funding is a key mechanism of change in the scientific norm system. Reward mechanisms influence so both the outcome and the evaluation of research.

According to Benner & Sandström (2000), funding agencies and sponsors contribute to the creation, reproduction and changing of the institutional setting of academic research. Funding agencies operate on three levels of influence, i.e. on the coercive, normative and cognitive levels. Such agencies´ operational routines and administrative structures shape the basis for public researchers´ project applications. The criteria for evaluation used by funding agencies influence the normative orientation among researchers and the decisions taken indicate for researchers the types of performance and organisations that are rewarded. Strategies of research sponsors influence both organisational models and normative orientations of researchers. The authors argue, moreover, that research sponsors have to be reformed if the transition to the knowledge-based society (that incorporates industrial, academic and political actors and places the university in a new relationship with industry) is going to be accomplished.

The dominant models of research funding, the intra-academic model and the top-down interventionist model seems to be replaced partly by a catalytic (non-regulating) one that involves academic and industrial interests in the consideration of research programmes. But there are counteracting tendencies. As a consequence, the conclusion drawn is that the forces of continuity and change are engaged in a process of negotiation about the normative setting of academic research (Benner & Sandström 2000).

The model of research funding with self-organised interaction between academia and industry may exist in parallel with a model of top-down control of academic-industrial interaction, and a more traditional model of research evaluation and reward (that has been the dominant in Denmark) where academic autonomy is central. The parallel existence may create tensions between the different models of research funding and foster different organisational fields and institutional orders. These tensions are unavoidable aspects of the reorganisation of academic research. Existing institutional structures have a tendency to hinder the development of new organisational settings. Therefore the path to a new norms system for academia is going to be extended. The authors claim: “Research funding is a battleground for the different agents with different strategies, and its

structure will be a crucial element in the development of new forms of knowledge production"[31].

The debate on tensions between academia and other societal agents usually has its origin in the differentiation of objectives and strategies between the sectors i.e. the perception of what is significant internally in academia relative to what is significant externally and what approaches/instruments are the most appropriate to achieve the objectives of the sectors. Hence, the central issue is to immerse in the knowledge reservoir and identify features where matching of internal and external interests can be possible. This implies though the development of trans-institutional norms for knowledge production within a socio-economic network that engages the interests of both academia and the private sector.

10.2. Building Capabilities

As acknowledged, increasing pressures for accountability in the public funding for university R&D has resulted in focusing on the value of practical and commercial benefits of academic research in terms of utility (Geuna 2001, Pavitt 2001). On the other hand, it is well known that uncertainties in the research and dissemination process make it particularly difficult to assess the value of research ex ante. Consequently, the main legitimation of academic research is based on building capabilities that could contribute to the realisation of options, most of which are unidentified when policy decisions are implemented. However, as Pavitt (2000) posits, "good science is useful science" and capabilities that have a foundation of good science are useful from a socio-economic perspective.

Capabilities can be built in cooperation with enterprises and industry to the benefit of both public and private research. The US accomplishment in science-based technologies is according to Pavitt (2001), to some extent based on research and institutions (with ability to generate first class capabilities) that are ranked highly by pure academic standards.

Building capabilities may also be related to the formation of companies, as recent research shows. However the relationship between university research and new company formation is for the most part not a direct one, and a range of factors influence the strength of it.

Lindholm Dahlstrand & Jacobsson (2002) argue that there is a direct or indirect relationship between the formation of capabilities and the formation of new firms.

[31] For a comprehensive discussion of research funding and normative settings in academia see Benner and Sandström 2000.

Moreover, the researchers claim: “the role university students may play for the transfer of university research into industry is often ignored or excluded in earlier studies of academic entrepreneurship (see OECD 2002). It is important that the university sector is able to educate a sufficiently large number of students with a knowledge/technological profile appropriate for both established organisations and new firm entry, and especially so in high-growth sectors of industry”. Lindholm Dahlstrand & Jacobsson (2002) describe this relationship in their analysis of a mapping of capabilities such as PhDs and MScs in different programs at Chalmers Institute of Technology and the formation of technology-based firms in the region of Western Sweden (where Chalmers is situated) during the period 1975-1993.

Research also shows that potential entrepreneurs rely mainly on the local labour market for engineers and scientists (Lindholm Dahlstrand 1999). This market is to a great extent influenced, in the Swedish case, by the responsiveness of the regional technical university. Accordingly the local availability of specialised labour has a direct influence on the size of industrial activities in fields demanding such specialised labour. For that reason the responsiveness of regional universities is expected to influence the volume of the training capabilities and so the potential number of technology-based entrepreneurs. There is hence, according to the authors, an indirect relationship between the responsiveness and openness of the university and new firm formation (cf. Dahllöf et al. 1998).

As the results of interviews with managers in the qualitative study presented here and the quantitative study of 600 managers (Graversen et al. 2003) illustrate, larger firms are also functioning as a “sponge” which absorbs much of the specific capabilities generated. Lack of capabilities is, according to Danish managers, one of the most important issues for science policy to focus on.

11. Discussion

11.1. General Observations

During the last years an intensive debate has taken place on the principles of research funding in Denmark. New governmental initiatives lead to a reorganisation of the supporting and financing structures of the RTD and innovation system. At the same time, a new legislation on the governance of universities was introduced with increased private sector representation at the governing board level. The general framework for a closer relationship between public and private research is nowadays more favourable. Recently, the Danish government presented a plan aimed at stimulation of the relationship and at facilitation of the interaction, especially targeting the small- and medium-sized companies. 275 million DKK were earmarked for this purpose (2004-07). In addition, universities have given room for separate entities to promote such interaction at market premises.

In Denmark the situation is not fundamentally different from other countries with high R&D intensity and well-developed infrastructures. The interaction between small- and medium-sized companies and public research has, according to recent research[32], increased considerably during the last years. However, the fact that only 3% of the enterprises have an actual cooperation with public research institutions, in combination with low public funding rates in relation to GDP at university level, highlights the need for persistent efforts to improve the framework for research interaction.

A recently published report[33] shows that Denmark isn't among the top seven most innovative countries. The investigation uses as criteria research funds, utilisation of research results and framework conditions for innovation activities. The results show, in a comparative perspective, that commercialisation of research results is not developed in the country. One problem is that only a limited amount of public research funding is used to finance research cooperation between the sectors. Denmark is lacking also regarding research-based companies that are spin-offs from universities. Managers express that they have limited access to technology, both in terms of technology produced in public service- and patent systems and the one produced in private companies. Danish companies are also lacking with respect to utilisation of knowledge and competence that producers and costumers have.

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[32] See The Danish Institute for Studies in Research and Research Policy 2003/ Forskningsstatistik 2001.

[33] See Nyholm & Langkilde (2003).

Mobility from enterprises to public research institutions is relatively low, mainly due to less attractive salaries in public sector research compared to the private sector. Immediate measures and incentives are required, but the problem is not easily solved. At present only few regulations influence the mobility of researchers. However no restrictions prevent researchers from seeking engagement in private companies. On the contrary the PhD programme is meant to facilitate such mobility. The tendency during the last years is also an increased mobility noticed among the younger researchers[34]. The main obstacle to mobility from enterprise to public research is the fact that research activities outside universities have not been considered a qualification in terms of advancement possibilities within the university system.

Having made this observation, it is obvious that temporary mobility between public research and enterprises could become an effective instrument to overcome cultural barriers, to influence attitudes and behaviours. There is little doubt that there is a lot to be done in promoting temporary mobility. A potentially important initiative is building capabilities and intensifying the Danish postgraduate programmes. The main goal may still be to increase the numbers of PhDs and the number of PhD employments in private enterprises.

In the discussion of barriers to interaction it is important again to highlight the different attitude in larger companies compared to small- and medium-sized. Large companies in general do not have difficulty in collaborating with public research institutions. Cooperation goes a long way back and partners have learnt how to manage the relationship. Companies have the capabilities and absorbing capacity that is a precondition for a meaningful interaction.

For many small- and medium-sized companies the picture looks different, although some progress has been noticed. Many lack the experience of cooperating with the universities and other public research institutes. One main barrier here is the lack of in-house capabilities and little or no information on the existing knowledge reservoir and potential gains of cooperation. In addition, the registered interest in university research is limited as uncertainty as to possible gains of joint R&D activities make companies reluctant to make investments. Consequently, cultural and normative barriers to public research are flourishing.

Diffusion of information on research activities and of knowledge through specific programmes especially targeting small- and medium-sized firms could benefit companies. This could be combined with initiatives on regional and/or local levels

[34] For a comprehensive discussion of research mobility issues in Denmark see Langberg & Graversen (2001).

that could match potential suppliers of knowledge with agents and/or demands on the market side. Other incentives may be the formation of regional and/or local networks enabling universities to further develop, in cooperation with companies, knowledge centres that provide technology services. This again could increase the capabilities and capacities of small- and medium-sized companies, at the same time as it creates a system of technology provisions influenced primarily by market demands.

It is obvious that there exists a problem of difference between a public research outcome and what is regarded as potentially marketable, even though science and technology are getting closer to each other and that the time-span between invention and commercialisation is decreasing. The time from invention to producing and marketing a product can be long depending on sector and technology level. On the other hand a difference between how innovativeness is defined in academia and in industry exists. This difference has its origin in the divergence of research objectives between the sectors (Jacob et al. 2003).

Academia defines innovation in terms of advances in knowledge, the provision of new subjects for further research and in improving or deepening understanding of processes (know why, how and what). Industry on the other hand defines innovation in terms of added value, new applications and relatively short financial revenues (Mansfield 1998). The two definitions do not exclude each other but they often have difficulty merging due to the fact that publication is the main performance indicator for researchers. For the same reason, researchers perceive commercialisation of results as a time consuming process (Jacob et al. 2003).

In conclusion, important barriers to interaction are differentiation in objectives of university research and enterprises R&D, differentiation in time-schedules, differentiation in cultures, values and norms, and the qualification and career system at universities and other public research institutions - based on solely academic criteria. Incompatibility in research activities, lack of absorbing capacities, lack of knowledge and interest in enterprises´ research abilities and in requirements linked to the specific market, are other obstacles. Other barriers are lack of economic and otherwise incentives for public researchers and reluctance to cooperate based on worries of losing scientific independency.

The main aim for policymaking may hence be to build capabilities and increase the competence level and societal relevance of research within universities and other public research institutes, particularly in areas of interest to enterprises too.

11.2. Influencing Attitudes and Behaviour

Influencing attitudes and behaviour of public researchers[35] or enterprises is difficult and will evidently take place over time. Incentives in this regard may also include new evaluation criteria and modes of advancement of public researchers. Intensification of awareness measures in both sectors, such as special awards, is another possible initiative.

Intensification of the programme of visiting or adjunct professors, i.e. researchers with professor competence employed in companies that work at the university on a part-time basis may function as a link between the sectors. Moreover, private sector researchers may be given increased opportunities to participate in postgraduate studies or in courses tailored to the specific needs of companies.

Focusing on the public research institutions, as Sandström & Benner (2000) argue and Gulbrandsen & Smeby (2002) confirm, the type of funding influences research orientations and outputs. Institutional structures play an important role in the emergence of new cognitive and organisational models within the academic system. Accordingly, industry funding seems to promote applied research rather than experimental development. A larger share of researchers with no external funding characterised their activities as development, compared to activities with industry funding (Gulbrandsen & Smeby 2002). Researchers with other types of external funding to a larger degree characterised their activities as basic research.

The above-mentioned studies show that researchers over time have become unwilling to answer questions of this character. According to the authors, this illustrates that boundaries between the traditional categorisation of activities in basic, applied and development become unclear as multi-, inter- and pluri-disciplinarity emerges. This could be an indication of a growth of Mode 2, or other new types of knowledge production, that to some extent make the traditional distinctions outdated.

As discussed earlier, Benner & Sandström (2000) argue that the institutional settings of academic research influence the way norms in the academic system are constituted via research funding. Funding is a key mechanism of change in the norm system. Reward structures influence the outcome on the one hand and the evaluation of research on the other. Benner & Sandström further argue that grant-giving agencies function as societal agents structuring research performance and the institutional norms of academic research. Actions taking place within the

[35] For a more detailed discussion of public researchers attitudes on research conditions, research and management see reports from The Danish Institute for Studies in Research and Research Policy (Langberg & Lauridsen 2001, Lauridsen 2002, Langberg 2003).

academic system are dependent on and structured by, funding agencies and sponsors. Such agents play a vital role in the process of redirecting the normative orientation and behaviour of individual researchers. Changes in research performance and interaction between research and various forms of social practice are related to the strategies of research sponsors. A process of negotiation about the normative setting of academic research is in progress.

Other studies show that faculties and research environments receiving industry funding are more positive to collaboration with industry and less concerned about potential negative impacts of contract research[36]. This can be perceived in several ways, as Gulbrandsen & Smeby (2002) notice in their study. Professors may have had positive experiences with contracts. Such contracts can introduce new and interesting research topics and be a precondition to costly and more exciting projects. On the other hand, the cultural setting, i.e. norms and attitudes may be different or changed during the process of interaction among the involved parties. It might also be the case that researchers with no industry funding (or at least some of them) avoid contract research because of concerns regarding potential influences on autonomy, intellectual property rights and other issues.

Recent studies show that Mode 2, or other new types of knowledge production that involve increased cross-sector co-operation, usually do not seem to conflict with more traditional academic goals and rewards (Graversen et al. 2002, Gulbrandsen & Smeby 2002). Autonomy during the research process is for instance high in dynamic and innovative research environments that have an intensive interaction with enterprises and society in general (Graversen et al. 2002).

However, researchers with industry funding have different collaboration patterns than researchers with other types of funds. Researchers with industry funding cooperate significantly more with all other types of researchers, including colleagues within the same department and researchers in other countries (Graversen et al. 2002, Kalpazidou Schmidt 1996). One explanation behind this is that applied oriented research demands further intense contacts with more research environments than basic research (Gulbrandsen 2000). Another is that dynamic and innovative environments are more open and have built an extended network. The fact that researchers with private sector funding and collaboration have more frequent contacts, both in academia and in the broader society and at the same time are independent (at least during research processes), may be taken as further evidence that there is no conflict between traditional academic science and newer types of knowledge production (Graversen et al. 2002).

[36] Compare with results by Graversen et al. 2002, Gulbrandsen & Smeby 2002.

When it comes to organisation and management issues, researchers with external funding show more positive attitudes towards research planning and coordination and more active management and leadership. As confirmed by Graversen et al. (2002) and Kalpazidou Schmidt (1996), external funding and collaboration (if that may be taken as an indicator of new modes of knowledge production) seems - according to public research managers and researchers with external funding - to require different types of research organisation and leadership (cf. Langberg 2003).

These studies show that department and/or research environment leadership should have greater autonomy and authority, play a stronger strategic role and influence the research environments and overall scientific profile and organisation. This is indeed the case in dynamic and innovative research environments, which demonstrate intense relations with enterprises. Their activity is based on extended external funding.

It seems that the Mode 1 against Mode 2 debate is not the central challenge for modern universities. The new challenge is rather the increasing complexity of knowledge production. Increased attention to the role of universities in national RTD and innovation systems, but also in the European context, has created a complex framework that intensified Mode 2 and other ways of knowledge production. The research system has nowadays an expanding and diversified funding basis, has adopted multifaceted communication patterns, has become further complex (with multi- and inter-disciplinary approaches) and is increasingly collaborative across-sectors. At the same time it demonstrates a high degree of internationalisation. This involves improved possibilities for funding through international channels and insight to practices in other countries.

It is obvious that inspiration from experiences in other similar countries and good practices could be useful. But to transfer the experiences directly and apply them in Denmark may not be the most fruitful approach. Lessons learnt in other contexts evidently must be adjusted before being applied to a Danish framework.

12. Implications for Research Policy

Framework conditions influencing the enterprises-public research relationship have to be considered in a policy perspective. It is important to keep in mind that the private-public relationship is only one element of the RTD and innovation system. It should therefore be studied and understood in the context in which it operates. This has to be the starting point also for research policy initiatives aiming to shape framework conditions that stimulate the exchange of knowledge and technology.

Some features of significance for research policy can be derived from the present study:

- Policy initiatives should have as their point of departure the characteristics of the market and the institutional framework.

- Policy initiatives related to enterprise-science relations should be accurate, comprehensive and have a long-term perspective. Such initiatives need a long time in order to achieve changes in structures, but also in actors attitudes and behaviour.

- Policy initiatives should aim to limit fragmentation and derive synergies in the RTD and innovation system.

- Initiatives should be taken aiming towards opening up of dialog between enterprises and public research and establishing formal and/or informal communication channels and platforms. There is a need for creation of a framework that facilitates informal contacts.

- Policy initiatives targeting public research in specific fields of strategic significance for the socio-economic development should be encouraged.

- Engagement of small- and medium-sized companies in an effort to increase the use of public research in enterprises. Companies that lack absorption capacities and capabilities to make use scientific knowledge should be supported. Specific measures and incentives targeting these companies could influence attitudes and practices.

- Engagement of small- and medium-sized companies with sufficient ability and absorption capacities should be encouraged and companies motivated to take initiatives related to public research activities. Adequate incentives should be introduced to this area.

- Common research programmes that support cooperation, especially thematically focussed programmes with a bottom-up approach and long-term perspective could prove effective and sustainable.

- The establishment of new or increased support to existing infrastructure, institutions and facilities that can be managed both by companies and public research simultaneously, and which may become a basis for long-term collaborations (beyond the support from public funding means).

- A competition-based approach of resource allocation related to cooperative research programmes can stimulate a larger number of joint (public- private) project applications. Those that get funding at the end of the selection process may serve as good practice for others.

- Initiatives and incentives that raise awareness among researchers on the commercial potential of their results, particularly in fields of strategic interest for RTD and innovation systems should be encouraged.

- Adjusting the institutional framework of public research to collaboration activities.

- Establishment of an effective infrastructure in public research that supports cooperation with enterprises and facilitates knowledge transfer.

- Establishment of specific institutes at universities and/or in public research institutes specialised in knowledge transfer. Such specialised institutes could, on a regular basis, adjust research strategies to changing environmental conditions and transfer knowledge direct to enterprises without interfering mediators.

- Adjust the framework of public research in order to provide institutional and individual incentives and rewards (in connection with evaluations of both individual and institutional activities).

- Encourage increased mobility between the private and the public sector, exchange and educate researchers and personnel (informal visits to each other). Increase education programmes tailored for researchers in the private sector at universities and public research institutions. Intensification of temporary mobility.

- Building capabilities that enterprises can utilise.

In conclusion, and in order to stimulate closer cooperation between enterprises and public research, research policy may consider particularly the market and identify successes and failures of it. Research policy should be based on a comprehensive knowledge of the public research institutions, their organisation, function, activities and their role in the RTD and innovation system. Companies on the other side should consider their role in the future RTD and innovation system in a national and an international perspective.

13. Concluding Remarks

As society "speaks back" to universities, research universities are facing problems of legitimation. In this context the traditional research universities are in a process of transformation. Out of the dialog between science and society, new types of universities are emerging that are untraditional in their mode of defining research processes and production, their evaluation of results and reward mechanisms, communication of results and dissemination. Hence the interaction between public research and society has been intensified. Enterprises evidently are one significant actor in this process of interaction.

One precondition for a more fruitful collaboration between academia and enterprise is mutual respect and understanding of the framework that they operate within and respect for the cultural settings in the two sectors. Likewise the interaction depends on the level of education in the companies and companies' ability to interact with universities and public researchers. The interaction further depends on the degree of awareness among researchers in the public sector on possibilities of cooperation and the awareness among companies of the potential benefits of collaboration with public research.

Evaluations of research should be modified accordingly in response to new demands of the socio-economic context. This implies that criteria for advancement and funding should comprise not solely traditional academic performance, but also criteria such as interaction with other actors in society.

However, research policymaking has to take into consideration that the more uncertain the research tasks, the harder it is to attract funding from the private sector. Accordingly policymaking has to consider that not all research is of immediate utilisation, nor can it always directly match narrow societal requirements or the immediate needs of enterprises. It is therefore of importance to pay continued attention to basic research and scientific fields that are not of immediate commercial interest. This should be done in order to limit risks of overlooking potential innovative research.

Research policy has also to take into consideration that some measures to make public research more “private-sector oriented” involves restricting of the amount of knowledge available to other researchers, at least for some time. In general, policymakers should keep in mind when forming research policy that while greater interaction is to prefer, there may be some risks involved in increasing the interaction and as a consequence primarily favour applied research. The risk is again to overlook future innovation.

EXECUTIVE SUMMARY

Objectives of the Study
The generation and utilisation of science in RTD and innovation systems has in recent years been the subject of increased attention. One dimension of a national RTD and innovation system is the relationship between public research and private enterprises.

The study presented here is an attempt to assess the role of framework conditions that influence the relationship between the public and the private sector. Since framework conditions may stimulate or impede this relationship focus has been on obstacles to establishing a better interaction between public and private research.

The study analyses the attitudes and perceptions of enterprise managers of the relationship between academia, i.e. universities and public research institutes and the private sector. The study is based on in depth interviews with a sample of 31 enterprise managers and a discussion of important theoretical perspectives on public-private interaction.

The main aim of the study was to:

- Map out managers' attitudes on and perceptions of the relationship between academia and enterprises.

- Identify barriers that impede high level of interaction between academia and enterprises and give suggestions on how to overcome such possible barriers.

- Provide information and suggestions on general conditions that intensify interaction between academia and enterprises.

In addition, the study attempted to provide information to policymakers on how to improve framework conditions in order to further stimulate and facilitate interaction between public research and private enterprises.

Main Results

The main results and their wider implications for policymaking are presented in the following.

Perceptions of Public Research

- Some parts of universities and public research institutes have established an intensive interaction with parts of the private sector and industry.

- The greater experience companies have from research co-operation with universities and other public research institutions the more positive the attitudes and perceptions are towards the interaction.

- The larger and (as is usually the case) more science- and research-based the company is (with a high proportion of research input out of the total input) the more it interacts with universities and other public research institutions and the more positive are attitudes on and perceptions of the interaction.

- Enterprises have difficulties in getting information on public research (information on know-who and know-how), especially small- and medium-sized companies.

- Enterprises with no experience from interaction with universities and other public research institutes have difficulties in overcoming barriers and in establishing a cooperation. This phenomenon is especially seen among small- and medium-sized enterprises that are not science-based and as a rule do not have researchers (and in many cases not even academics) employed in their company.

- In general, attitudes towards the enterprise-academia relationship vary depending on characteristics of the market actors and the composition and structure of the private sector on the one side and the public sector on the other. In general, attitudes among small- and medium-sized enterprises are not particularly positive either due to (a) lack of compatibility of knowledge and knowledge asymmetries, (b) lack of information on the existing knowledge reservoir and (c) lack of absorption capacities.

- Considerable differences are found in the perception of research objectives of public research institutions and universities on the one side (many engaged in long-term, basic research activities) and those of

industry on the other (have as a rule short to medium term objectives and are product oriented, except among the larger science-based companies).

- The perception of strategies and instruments used in public research varies among managers. Two main categories have been identified. The majority of managers claim that strategies and instrumentation in public research are highly different from such used by enterprises. This is basically found to be due to differentiation in objectives, demands on markets, market mechanisms and competition. Others claim that contemporary universities adopt strategies and make use of similar instruments as enterprises, in order to attract continued funding in a highly competitive environment.

- Enterprises and science institutions use a variety of channels (some formal and/or mainly informal communication and contacts are used) in the interaction process.

Barriers to Interaction between Private Enterprises and Public Research
The main barriers identified by the managers can be summarised as follows:

Structural and contextual barriers

- Difficulties in getting information on public research and the existing knowledge reservoir.
- Difficulties in matching knowledge supply and demand.
- Information asymmetries (open public research versus closed private enterprise and limited market transparency).
- Different, and in many cases incompatible, objectives.
- Uncertainty of outcome in public research – high-risk research/large spill-over.

Institutional settings

- Public domain mentality of universities (bureaucracy, “Ivory tower”, inefficient organisation and long-term perspective research).
- Lack of understanding regarding corporation, business and commercialisation of research results.
- Bureaucracy and inflexibility of administrators and researchers.
- Poor marketing/technical/negotiation skills and marketing orientation of universities.
- Lack of resources devoted to research and technology transfer by universities.

- Universities are some times too aggressive in exercising intellectual property rights (especially in relation to publication).

Legislation, regulation and policy

- Lack of motivation and reward mechanisms for public researchers with respect to engagement with enterprises.
- Lack of capabilities at universities that enterprises could utilise.
- High transaction costs from enterprises to universities – financing restrictions.

Differentiation in working culture, norms and values

- Divergent cultures.
- Universities are closed systems that are not interested in cooperation.
- University researchers do not understand corporatism and are not interested in understanding it.
- Only some fields (limited in numbers) are of interest for the enterprises.
- Universities are not interested in business and commercialisation of research results.
- Universities are bureaucratic and based on inefficient, not flexible organisation that have difficulty to cooperate with enterprises.
- The perception of time and pace of the activities is different in the two cultures (public research is slow and time consuming).
- Public researchers have unrealistic expectations regarding the value of their research.
- University researchers are driven by curiosity and interest, while the bottom line in the enterprise culture is profit.

In an international perspective these barriers are not only characteristics of the Danish entrepreneurial scene, but are features common in other countries too. As regards the situation in Denmark in particular, the survey has identified five main features that can be subject to a specific research policy initiative. The features are:

- Lack of information on public research that enterprises can utilise.

- Lack of capabilities that enterprises can utilise.

- Lack of communication (and informal contacts) that can improve understanding of the cultural and normative settings.

- Lack of incentive structures and institutional settings in public science that can motivate researchers and facilitate interaction with enterprises.

- Lack of possibilities for absorbability of research by small- and medium-sized companies with little or no academic capabilities. This is a feature that characterises the Danish private sector in general.

Suggestions for Improvements of the Relationship

In order to improve the relationship between the private sector and public research the following observations are of significance according to managers of enterprises. Universities could:

- Educate staff better in order to overcome informational and cultural barriers.
- Build more capabilities that enterprises can use.
- Devote more resources to research and technology transfer to industry.
- Develop a system that provides easy access to their knowledge reservoir (access to know-how and know-who) and describe how collaboration can be established.
- Institutionalise systems, mechanisms and expertise to handle research and technology transfer.
- Develop more forceful market orientation and marketing skills.
- Give more attention to, and focus on, fields of science of high economic importance.
- Increase the strategic planning by adjusting to the economic development in the country.
- Improve management and leadership of research.
- Increase the networking between scientists and enterprises.
- Improve the reward systems for research and technology transfer activities.
- Motivate and give incentives to public researchers in order to increase cooperation with enterprises.
- Be less forceful in exercising intellectual property rights.
- Be less forceful in exercising publication rights.
- Universities and enterprises can devote more time and efforts to develop mutual understanding and establish informal contacts.

Companies on the other hand (particularly the small- and medium-sized companies) should according to managers, upgrade their organisations and adjust production to demands of the new economic environment.

The results presented above, confirming the results of previous research highlight the similarity in problems (with few exceptions) that most of the RTD and innovation systems in Europe are facing. Research policy should consider incentives that can more effectively stimulate public-private linkages.

Implications for Research Policy

The following are some features of importance for research policy, as derived from the study:

- Policy initiatives should have as their point of departure the characteristics of the market and the institutional framework.

- Policy initiatives related to enterprise-science relations should be accurate, comprehensive and have a long-term perspective. Such initiatives need a long time in order to achieve changes in structures, but also in actors attitudes and behaviour.

- Policy initiatives should aim to limit fragmentation and derive synergies in the RTD and innovation system.

- Initiatives should be taken aiming towards opening up dialog between enterprises and public research and establishing formal and/or informal communication channels and platforms. There is a need for creation of a framework that facilitates informal contacts.

- Policy initiatives targeting public research in specific fields of strategic significance for the socio-economic development should be encouraged.

- Engagement of small- and medium-sized companies in an effort to increase the use of public research in enterprises. Companies that lack absorption capacities and capabilities to make use scientific knowledge should be supported. Specific measures and incentives targeting these companies could influence attitudes and practices.

- Engagement of small- and medium-sized companies with sufficient ability and absorption capacities should be encouraged and companies motivated to take initiatives related to public research activities. Adequate incentives should be introduced to this area.

- Common research programmes that support cooperation, especially thematically focussed programmes with a bottom-up approach and long-term perspective, could prove effective and sustainable.

- Establishment of new or increased support to existing infrastructure, institutions and facilities that can be managed both by companies and public research simultaneously, and which may become a basis for long-term collaborations (beyond the support from public funding means).

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- Initiatives and incentives that raise awareness among researchers on the commercial potential of their results, particularly in fields of strategic interest for RTD and innovation systems should be encouraged.

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- Establishment of an effective infrastructure in public research that supports cooperation with enterprises and facilitates knowledge transfer.

- Establishment of specific institutes at universities and/or in public research institutes specialised in knowledge transfer. Such specialised institutes could, on a regular basis, adjust research strategies to changing environmental conditions and transfer knowledge direct to enterprises without interfering mediators.

- Adjust the framework of public research in order to provide institutional and individual incentives and rewards (in connection with evaluations of both individual and institutional activities).

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- Building capabilities that enterprises can utilise.

In conclusion, and in order to stimulate closer cooperation between enterprises and public research, research policy may consider particularly the market and identify successes and failures of it. Research policy should be based on a comprehensive knowledge of the public research institutions, their organisation, function, activities and their role in the RTD and innovation system. Companies on the other side should consider their role in the future RTD and innovation system in a national and an international perspective.

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APPENDIX

Table A.1. The significance of public research (classification in scientific fields) for the development of company knowledge during the last 10-years period. Percentage.

Share of managers estimating that knowledge from public funding and research has a **high or very high significance** for the development of company's knowledge reservoir			
Scientific field	R&D intensive companies	Other innovative companies (no R&D activities)	Non-innovative companies
Physics, mathematics, Information technology and technology			
Physics	11	3	4
Mathematics	7	6	5
Information technology and technology	24	23	21
At least one of three options	**27**	**23**	**22**
Biology, chemistry and medicine			
Biology	11	3	3
Chemistry	14	5	5
Medicine	6	2	0
At least one of three options	**19**	**5**	**7**
Social sciences and humanities			
Economics	5	9	8
Law	2	6	2
Humanities	1	3	2
At least one of three options	**6**	**11**	**8**
At least one of the above mentioned nine options	**36**	**24**	**25**

Table A.2 The significance of a range of research policy initiatives based on company characteristics. Percentage.

Share of managers estimating a range of research policy initiatives as having **high or very high significance**					
Characteristics of company	Research policy initiatives				
	Increased funding to research in general	Increased funding to fields/cooperation	More funds to enterprises	Changed university leadership	Public research in general *)
Innovation cooperation					
No cooperation	56	50	46	26	44
Cooperation, any	59	58	51	45	59
Cooperation with research institutions	66	64	54	46	67
Patents					
Have applied for patents during the last three years	64	61	57	49	65
Have not applied for patents during the last three years	55	52	46	33	49
Export					
None ex port in 1998	61	45	46	26	46
An export share between 1 and 50 pct of the total turnover in 1998	54	59	48	43	55
An export share that is over 50 pct of the turnover in 1998	59	58	52	43	58
Number of employees					
Under 10 employees	67	52	47	9	50
Between 10 and 49	53	53	51	34	44
Between 50 and 249	55	56	49	41	52
Over 249	65	56	47	48	70
Branch					
Manufacture industry	52	53	54	40	52
Knowledge intensive business	68	57	47	31	53
Other branches	56	56	35	46	60
Total	**58**	**55**	**49**	**38**	**54**

Note: *) Indicates share of managers that perceive public R&D as excellent or satisfactory.

Table A.3. The significance of knowledge acquired from public research institutions and universities for innovation activities in companies. Percentage.

Share of companies assessing that knowledge produced in public research institutions and universities has **a high or very high significance**		
Knowledge acquirement	R&D intensive companies	Other innovative companies (none R&D activity)
Knowledge		
Publications and technical reports	21	9
Public conferences and meetings	11	3
Informal contacts between employees and researchers in public research institutions and universities	22	3
Recruiting		
Employment of experienced public researchers and technicians	29	8
Exchange of personnel between the company and a public research institution	10	0
Cooperation		
Contract research produced by a public research institution	11	2
Joint research projects together with a public research institution	19	5
At least one of the above mentioned approaches	**48**	**20**
Public research institutions or universities used in general as knowledge sources	**24**	**5**

Table A.4. The significance or use of different knowledge sources. Percentage.

Share of managers estimating that knowledge sources are of a **high or very high significance** for their innovation activities or **have made use of/wish to make use** of these				
Knowledge source	R&D intensive companies		Other innovative companies (none R&D activity)	
	High or very high significance			
Knowledge acquired from public research institutions or universities				
In Denmark	21		3	
In other EU countries	13		2	
Non EU countries	11		2	
At least one of the above mentioned options	**24**		**5**	
Knowledge acquired from public research institutions or universities				
Publications and technical reports	21		9	
Public conferences and meetings	11		3	
Informal contacts between employees and public researchers	22		3	
At least one of the above mentioned options	**34**		**12**	
	Have made use of	Wish to make use of	Have made use of	Wish to make use of
Contacts with public research institutions or universities				
Receiving of newsletter from research institutions	28	36	0	46
Participation in enterprise targeted conferences/seminars	39	35	15	50
At least one of the above mentioned options[*)]	**44**	**49**	**15**	**62**

Note:
[*)] Share of managers that have made use of and wish to make use at least one of the options are not excluding each other.

Table A.5. The significance of use or wish to make use of different types of cooperation. Percentage.

Share of enterprise managers estimating cooperation as having **high or very high significance** for their innovation activities or that **have made use/wish to make use** of different types of cooperation

Type of cooperation	R&D intensive companies	Other innovative companies	Non-innovative companies
	High or very high significance		
Knowledge acquired from public research institutions or universities			
Contract research produced by a research institution or university*)	11	2	•
Joint research projects*)	19	5	•
At least one of the above mentioned options	**21**	**5**	•
Barriers			
Lacking contact with public R&D environments	12	15	30
	Have made use of		
Cooperation			
Public or private research institutions or universities in EU countries*)	45	7	
Public or private research institutions in other than EU countries*)	11	0	
At least one of the above mentioned options	**48**	**7**	

	Have made use of	Wish to make use of	Have made use of	Wish to make use of	Have made use of	Wish to make use of
Type of contact						
Contracts with university researchers	25	16	0	12	1	4
Contracts with university institute	26	16	0	0	0	6
Use of industry PhD programme	22	17	0	19	1	7
Cooperation within research parks	17	31	0	19	0	7
Use of GTS-institutes	28	23	12	46	12	19
At least one of the above mentioned**)	48	53	12	62	14	30

Note: *) Managers of non-innovative companies are not included.
**) Share of managers that have made use of and wish to make use at least one of the mentioned options are not excluding each other.