

Boundary Organizations and SMEs University - Industry Relations i Denmark

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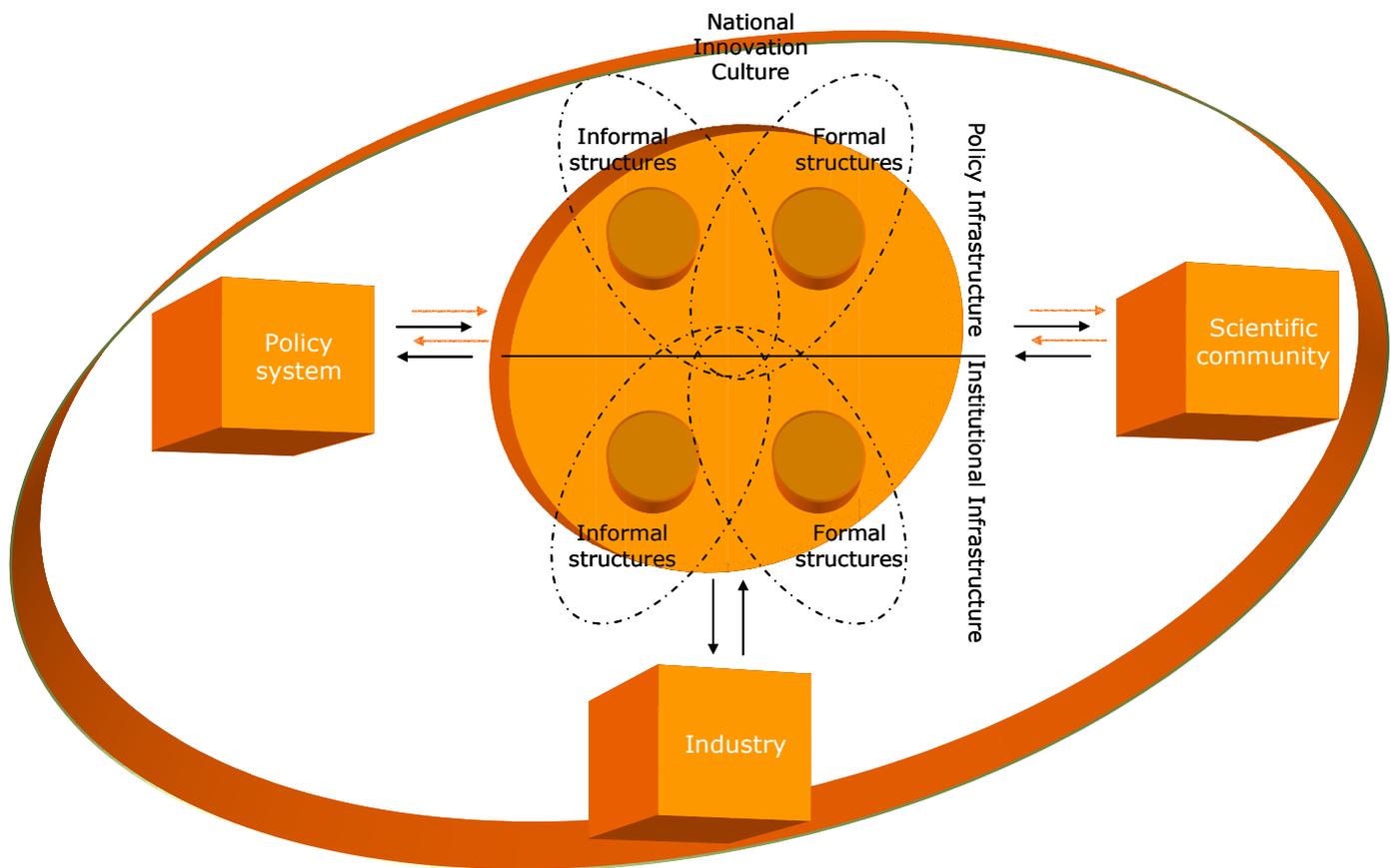
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Boundary organizations and SMEs – University-Industry Relations In Denmark

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Executive Summary

In the knowledge society the production of knowledge is seen as the most important factor of production.

The purpose of this thesis is to investigate the concept of research collaboration in a broad context - with the intention of pinpointing organizational, political and managerial forces influencing the level of research collaboration and derived level of innovation in Denmark.

The thesis sets out in an international setting analyzing and investigating the producers of knowledge on a broad theoretical foundation. Firstly, time is devoted to examining the framework of three entities, namely industry, universities and society.

In a contemporary perspective, historical and social developments of these three are expounded in an international context with focus on collaborative and innovative elements.

Building on the foundation of the international study the thesis sets out to theoretically define and investigate the actors in the knowledge producing sector in a Danish context leading to the formulation of a model of this sector. As empirical foundation a qualitative analysis of four archetypical knowledge producers and one science-based small and medium sized industry is conducted.

The theoretical and empirical approach forms the groundwork for a scenario approach investigating certain future possibilities in the field of knowledge production in Denmark. These three elements finally form the base for conclusion focusing on three areas: industry, university and mediating institutions.

The conclusion proposes – through a division in outlook/perspectives and epilogue – policy recommendations, strategic possibilities and identifies the most emergent barriers and trends for research collaboration in Denmark.

Preface

This thesis is representing the completion of the Master of Science program in Information Technology (e-business) at the IT University in Copenhagen. The overall aim of this thesis is to analyze the area of research collaboration between actors in the Danish innovation system.

The thesis takes its point of origin on a range of courses taken during the master programme, where I've focused on the coupling of knowledge and innovation. The most important in that sense, are knowledge management, project management, innovation and entrepreneurship to mention a few.

The knowledge and theoretical foundation of the thesis, rests on knowledge gained from numerous sources such as: Academic literature, literature presented at conferences, survey conducted using interviews, reports, interaction with fellow students as well as other sources.

At this early point it will be necessary with a preliminary discussion on the terms used throughout the thesis. As a prefatory note, I would like to draw the attention towards the use of the terms research, science and knowledge production - both due to the overlapping of these three terms and also due to their various occurrences in the literature that I've used.

Evidently, the terms are used interchangeably in the contemporary literature, although their actual meaning differ slightly from one another. Nowotny et al 2001 provide an explanation of the two terms:

*“ ‘Research’ is now valued more highly, explicitly and implicitly, than ‘science’. Its capacity to bring forth the unexpected – in short, the latest stunning results and exciting new findings of ‘research’ – is most highly valued by policymakers, researchers, the media and even by the general public. Of course ‘research’ cannot flourish without ‘science’ – the institutional infrastructure, the transmission of knowledge and training of the next generation, the systematization of knowledge”.*¹

During this thesis I will not aim at maintaining a clear distinction between these terms, and will follow the track of most of my references by using science and research as similar descriptions, and by applying the term knowledge production as a modern synonym of the two.

Acknowledgements

Many people have contributed to the process of writing this thesis and given support as I went along. First of all my appreciation goes towards my advisor Søren Wenneberg who, from day one, has made an extraordinary contribution to the final project. Line Gry Knudsen and Christian Vintergaard for both interesting conversations on central and boundary issues and for social engagement during the process. All my gratitude goes to my eight month old daughter Filippa, who apart from giving me wonderful smiles during hard times has behaved extraordinary fine by sleeping more than you would expect from a new born baby. And to her mother for taking care of everything!
Enjoy!

Copenhagen, May 2002

Kasper Birkeholm Munk

¹ **research:** a detailed study of a subject, esp. in order to discover (new) information or reach a (new) understanding

science: (knowledge obtained from) the systematic study of the structure and behavior of the physical world, involving experimentation and measurement and the development of theories to describe the results of these activities

- A science is a particular subject that is studied using scientific methods.

- The science of something is the whole body of knowledge that has been built up about it.

knowledge: understanding of or information about a subject which has been obtained by experience or study, and which is either in a person's mind or possessed by people generally.

production: the process of making something/to bring it into existence.

Source: Cambridge Dictionaries Online, <http://dictionary.cambridge.org>

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1. Introduction

1.1 Opening

One of the most remarkable features of the last few hundred years has been the rapidity of the transfer of new scientific understanding into everyday life (Ziman 2001).

Access to information, competencies, networks and ultimately knowledge has become widely recognized as a very important necessity for successful innovations in society today (Unger 1999). This is stressed out in both neoclassical growth models and other approaches of the economics of science and technological change, using the concepts of production and distribution of knowledge to explain economic growth.

Globalization, de-regulation and information technology are some of the most used terms when speaking about the world we live in today.

Especially the concepts of technological development, changing market structures and the knowledge society are frequently used to describe the environment of business and economy. These entire buzz words constitute a new era – a new era in which both individuals and organizations operate and navigate in an increasingly complex and internationalized environment.

The ever-rising use and impact of the Internet and use of information and communications technologies in all areas of society has had a considerable effect and played a major role in the development of both science and society - expanding the potential for collaboration not just within institutions and organizations, but also between institutions and organizations (Ziman 2001). Certainly the benefits of this development are not equally available to all, but no institution committed to the promotion of science would lack convincing examples of the value of science to the enhancement of society.

Through the last decades an increased focus on science and knowledge production has emerged – in Denmark and the rest of the world. In the knowledge society, technological conquests and the production of knowledge are seen as driving forces in the pursuit of steady economic growth. The coupling of technology and knowledge production has two quite different strands or two very distinct characteristics. Firstly, knowledge and technology has produced lots of new products and concepts being utilized as source of economic growth and secondly, these two factors constantly bring up new insights and therefore new areas of research - an open-ended process that can only be satisfied by using more science and technology (Ziman 2001).

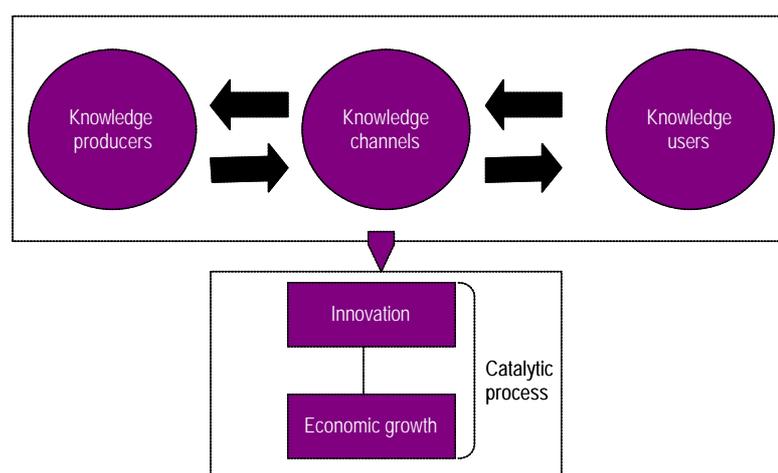


Figure 1.1 – Innovation as the linkage between the knowledge system and economic growth²

This dependency relationship between economic growth and knowledge production widely affects the mere concept of research carried out in both public and private institutions. Innovation is regarded as a precondition for the linkage between research and economic growth, operating as a catalyst for the generation and application of new knowledge.

² The knowledge allocation system functions as a two-way process supported by knowledge channels of both formal and informal character. The organizations and individuals in the system are represented as both users and producers of knowledge. As a catalytic process innovation leads to economic growth through capitalization of knowledge drawn from the system. (Source: own production)

In the knowledge economy the domains of state and market, of culture and mass media and of public and private arenas have partially been eroded. By bringing such diverse players into the game a new ‘fuzzy’ setup has arisen with political, cultural and industrial forces influencing research and knowledge production in contemporary society, characterizing society with both pluralism and diversity and more noticeable volatility and transgressivity (Nowotny et al. 2001)

The same ‘fuzzy’ picture applies for the concept of science. The melting together of political, cultural and industrial scopes eradicates the boundaries of these former separate spheres. Following, the autonomy of science, or the boundaries of science are disappearing and have pushed science into more contextualized arenas (Nowotny et al 2001)³. The element of contextualization is a natural consequence or derivative of political, social and industrial forces influencing knowledge production. Traditional criteria for quality assessment in science are torn down, and instead of using the community of specialist to legitimate science the testing ground is now application. Additional criteria are therefore added to embrace intellectual as well as social, political and economic perspectives. The context of implication – what new insights and knowledge means to further research and the context of application – how we can apply new insights and knowledge to gain economic advantage are now seamlessly attached to one another.

To sum up – all of the above factors has led to an increased focus on science - concerning both the way research is carried out, but also which actors that has to do research (Wenneberg 2000, Ernø-Kjølhede 2001, Gibbons et al 1994, Etzkowitz and Leydesdorff 1997 and 1998)

³ Contextualize is the event of bringing something into context.

1.2 Contemporary University-Society relations – a historical perspective.

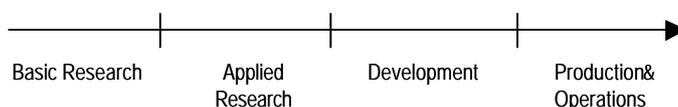
Following the path of the opening it's obvious that there are two parallel processes happening – one transforming society and one transforming science. When trying to understand the significant changes happening to both society and science it seems indicative that the processes are not working in arms length, where changes in society directly affects the scope of science vice versa. Rather one should look at the changes as a co-evolutionary process – a dichotomy of society and science and of social and epistemic effects with mutual dependencies. (Nowotny 2001)

Through an increased focus on knowledge production by means of economic growth, performance and regulation of universities constitutes a new 'field' has emerged - a field consisting of industry, state and academia integrating political, industrial and academic interests, in the conduct and regulation of research, politics and economic activities.

In a historical and social perspective, universities have always played an important role in the creation of knowledge. As knowledge institutions universities are responsible for the diffusion of knowledge into society and they are one of the main reasons of our technical expertise and mastery of nature. But their role has undergone many changes and transformations since the first universities emerged in the Middle Age (Siggaard Jensen 2000, Wittrock 2000). The primary task for the medieval universities was to educate students. But undergoing what is designated the 1st academic revolution during the 19th century (Wittrock 2000, Etzkowitz 2001) a new dimension was added to the core capabilities of the university, namely research. Instead of being primary teaching institutions for the youth, the concept of research was institutionalized. Thus, the modern university emerged during the 19th century, and not before that period did the universities take up their task as primary knowledge producers in society. Not before that, did the

idea of the research-based university become prevalent. Acknowledging that the use of research from universities could lead to economic prosper ensured the support for the universities and ensured continuous growth and development following the prescription of 'Science, The endless frontier' – a very important document written by Vannevar Bush in 1945⁴. The paper came to be one of the most opinion-forming documents both in the US and outside.

The notion of 'the endless frontier', was both seen to secure freedom and autonomy⁵ in the pursuit of basic science, and additionally reasoned that basic science was the means to secure ongoing socio-economic gains. The paper ended up being one of the main tools in securing continuous funding to the universities, and fostered the immensely popular linear model of innovation, postulating a one-dimensional innovation process where the different phases in the model were working in arms length rather than as a complex multi-dimensional process (Guston 2000)



Figur 1.2: The linear model of innovation⁶

By linking basic science and economic growth and emphasizing this relationship, funding became an important factor in society-university relations. The relationship, known as the social contract between society and the universities, was based on mutual trust (Guston 2001) – in the sense that public funding of the research at universities would lead to both qualitative and quantitative knowledge to be used in the interest of

⁴ Vannevar Bush presented the paper in 1945, in his role as director of scientific research and development (OSRD) and the advisor of President Roosevelt. (Bush 1945)

⁵ Autonomy of science describes a situation where science and scientists are left to self-regulation, placing science in a vacuum outside the reach of direct social control and political agendas. That way scientists and researchers have maintained a motivation and an independency securing basic research based on the researchers own interest - unveiling fruitful insight in reality as it is.

⁶ Source: Stokes 1997, Guston 2000

securing socio-economic goals and maintaining either consolidation or improvement of a nations competitiveness. As a reward society would secure autonomy of science, which seemed to be an indispensable precondition for efficient, high-quality science (Stokes 1997). The underlying arguments of the social contract were really founded on the work of Robert K. Merton, who, already in 1942, identified (CUDOS):

- **C**ommunism, (common ownership of goods (knowledge))
- **U**niversalism, (truth claims are not to be subjected to pre-established impersonal criteria such as nationality, gender, race etc.)
- **D**isinterestedness (researchers should be emotionally detached from their field of study, pursuing truth open-mindedly. Furthermore science should be kept out of political and economic interests)
- **O**rganized **S**cepticism (researchers have to be critical towards the work of others, but also towards their own work)

(Ernø-Kjølhede 2000, Ziman 2001, Guston 1997, Nowotny et al 2001)

as a coherent set of guiding norms of the scientific community -

essential for a good environment where pure science could flourish.

The CUDOS norms seemed to be prevalent during the war and a shorter post-war period (Nowotny et al 2001). But the whole foundation of the university and its conduct of basic science was challenged by the emergence of new dynamic research areas as life science and biotechnology. Furthermore the emergence of research centers with strong linkages to the industry enlarged the number of knowledge producers, and implicitly the number of applicants to the sources of funding. The above-mentioned changes in the conduct of science and in the institutional landscape increased the divergence between ideal and actual practice of science⁷. It seemed clear that Bush' paradigmatic articulation of the relationship between basic science and technological

⁷ After WWII, education was offered as a common good and was seen as an important factor in building up and securing the democratic norms in society. Therefore, the number of students finishing university education has increased ever since – an increase that can't be absorbed by the traditional academic institutions. Thus, a larger and larger group of highly trained academics are employed with non-academic knowledge production.

Source: Wittrock 2000

innovation – a science push model⁸ - was inadequate to create the conquests required to compete in a world economy characterized by growth in complexity, unpredictability and irregularity in both society and science and an emergence of transgressive institutions and blurring of the former well-defined state, market and culture. (Nowotny et al 2001, Etzkowitz 1998, Benner 2000)

The non-intervention policy approach was gradually deviated from leading to a more active role of the state in prioritizing and planning publicly funded research (Ernø-Kjølhede 2001, Etzkowitz 1989). Having seen the revolutionary effects of basic knowledge in medicine, warfare etc., growing disappointment with the speed of diffusion from the academic world was fostered. The 'invisible hand' – the mechanism securing a correct allocation of resources – anachronisms of both Adam Smith in 1776⁹ and Polanyi (1962)¹⁰ - was replaced by a policy pull strategy.

1.3 Post academic research - the industrialization of knowledge

Abandoning the scientific ethos, the Mertonian norms, and focusing on policy initiatives to foster the cooperation between science and society constitutes a decisive break with the academic tradition during the first part of the 20th century. The changes and transitions witnessed are not merely transitional and temporary but are part of a complex scheme of interlinked external and internal changes affecting the procedures and principles of science, society and policy (Ziman 2001). Bundling these changes in relation to the academic sphere these transitions constitute the 2nd academic revolution or the 'new

⁸ Science push characterized the approach that basic science automatically leads to economic gain as reasoned in the linear model.

⁹ The 'invisible hand' is the economist Adam Smith's (1723 - 1790) characterization of the way the capitalist system works or ideally might work. Smith put forward his ideas in his book, *Inquiry into the Nature and Causes of the Wealth of Nations* (1776), which is still regarded as a bible of classical economics.

¹⁰ Michael Polanyi, describes science as an invisible hand process - the self-coordination of independent performers of scientific work. (Guston 2000)

production of knowledge' and have established themselves in all epistemic institutions, from universities over governmental research institutions to industrial laboratories (Etzkowitz 2000, Ziman 2001, Nowotny et al 2001).

What is essential to draw from this epistemic development is, as noted above, the application of basic science to practical problems in society. From an institutional point of view, we still find the universities at the top of the hierarchy of research institutions or knowledge producers yet increasingly in competition or collaboration with governmental sector research institutions, private research institutions and consultancy businesses employed with knowledge production. Constituted by academic and national traditions the university seems to have entered the knowledge society with a certain entrepreneurial format (Ziman 2001, Wenneberg 2001a)¹¹. This transformation seems to be the result of both internal drivers and the emergence of external forces that derives from the focus on knowledge-based innovation.

With an increased focus on applicable research the concept of science is altering and given new meaning. Politically, the concept of research management has evolved and the creation of a trans-disciplinary science system where both public and private knowledge producers interact is one of the main issues at the moment. Science and research is to be seen as a mass activity involving both private and public spheres where team based research groups work together in the production of knowledge.

¹¹ As research institutions the universities must be regarded as, indeed, very special institutions embedded with a certain characteristic that private research institutions haven't got. That certain characteristic is concerning the inflow of students and represents a key asset for the universities. First of all students are knowledge users, continuously in demand of knowledge during their education. At the same time the pool of students represent a potential group of future knowledge producers. Thus, the students are fueling the further production of knowledge. Taking a closer look at that characteristic, it's quite obvious that no organisation - not even high growth businesses can manage a flow-through of the same dimension. *Source:* Basic inspiration comes from speech held by H. Etzkowitz 2001 at REMAP seminar autumn 2001.

Extracting the most observable facts from above, some of the novel, yet very general research trends can be identified as:

- ***Focus on relevance and application in society***
(Nowotny et al 2001, Gibbons et al 1994, Ziman 2001, Wenneberg 2000)

In securing a country's competitive advantages and a welfare system based on growth it is important to capitalize on research to maintain a steady growth in the individual country.

- ***Research based on the interaction and cooperation of private and public research teams – with the aim of providing solutions to practical problems.*** (Ziman 2001, Nowotny et al 2001, Gibbons et al 1994)

Due to increased complexity and intensity of research the individual researcher has to participate in team-based research. Innovation is seldom carried out in seclusion, but is happening in trans-disciplinary networks.

- ***Increased demands for efficiency and transparency***
(Nowotny et al 2001, Ziman 2001, Gibbons et al 1994)

Science and research is no longer accepted as being unquestionably valid and true. The criteria for evaluating the utility and values of research have changed. Quality and the assessment of quality will, in the future, be more based on the negotiation of legitimate criteria – where the criteria will change from research field to research field, from project to project.

- ***Lack of public funding*** (Ziman 1994 and 2001, Gibbons et al 1994, Nowotny et al 2001)

In a world of increasing competition in the field of knowledge production, funding has become a very important factor. At the same time researchers are confronted with cutbacks in public funding. As to be sure that funding, public as well as private, arrives at the right places at the right time, there is a need for prioritizing and management of this 'allocation'-process.

In other words, a convergence during the last 3 decades has brought three relatively separate worlds – public research, the private sector and public policy - closer together bringing about an increased interaction and cooperation crossing disciplinary, institutional and national borders (Etzkowitz and Leydesdorff 1995, Etzkowitz 1998, Gibons et. al 1994, Benner 2000).

1.4 Problem identification

In the wake of the above description of the trans-disciplinary knowledge-producing sector, one has to reflect on the changes that I've put forward. In what light should these overall changes be regarded? One thing is for sure – the mentioned changes will or are already having immense effect on research in its original sense. It's important not to try to lump all the significant changes that have occurred in both modern society and science together and label them as features of the 'new' economy. If one wants to understand the contemporary environment and build trajectories into the future systematic investigation of the drivers is essential.

The development towards knowledge production in the context of application, expansion in the scope and amount of scientific research and the emergence of many new knowledge-producing institutions, gives rise to a very immense and direct overlapping between science and society. This overlapping is seen in the melting together of state,

market and culture – or more explicitly of the three spheres: universities, government and industry.

This overlapping is the object of research by many scientists - specifically two directions have, during the last decade, established themselves as explanatory models or theories of the changes in science and society, namely the concept of the 'Triple Helix' (Etzkowitz and Leydesdorff 1995, Etzkowitz 1998) and the formulation of 'mode 2 knowledge production' (Gibbons et al 1994, Nowotny et al 2001). These two theories will be dealt with from time to time in forthcoming chapters.

On macro level the use of science policy and research management are indicators of the transition to a new regime for science. The objectives inherited in research policy are complex, yet in relation to public assessment of science it has to respond to two interdependent goals (Guston 2000, Ziman 2001):

1. to assure the integrity and reliability of publicly funded research(Ziman 2001)

This point refers to the norm of disinterestedness as described in chapter 1.2. Historically science has provided society with theoretical reflection into real-life phenomena and this has been the guiding lead. Hereby not said that science has to produce the ultimate truth, yet providing with reliable knowledge that can lead society in the correct direction is important. As noted above an increasing demand on public research to present socially applicable research that can be utilized for growth and welfare enforces this point even stronger.

2. to assure its productivity(Guston 2000).

High productivity in research is seen as a key factor in getting innovative ideas to the market. This form of applicability has become a dominant theme in science-society relations where science is expected to deliver novelty with increasing efficiency to stimulate growth and

welfare creation. As public funds are granted to the universities returning valuable research is seen as an imperative.

The durable factor in science policy is therefore the mutual relationship between the funding part and the researcher, presented by a situation of asymmetric information between the conducting part and the governing part. This problem will be presented and analyzed in chapter 4. Moreover, research management's incentives about creating increased cooperation and networking across disciplinary and institutional borders has proven to impinge on the way research or knowledge production is carried out. Generally, the more support granted for an area of research the more political activity it entails.

This new set of epistemological objectives (transparency, efficiency, relevance, application etc.) needs to be implemented and worked in throughout the spectrum of knowledge producers – a process that raise important questions. Which opportunities and constraints can be identified in the trans-disciplinary and trans-institutional setup? Is it a clear possibility that the new objectives strengthen the knowledge production – or is it a restraint for traditional basic research? In other words, how do we balance freedom, autonomy, truth and originality with effectiveness, transparency, efficiency and economic growth? (Wenneberg 2001 a-e, Gibbons et. al 1994, Nowotny 2001, Ziman 2001)

On meso level one finds a group of relatively new types of organizations specialized in mediation between the public and the private sphere. In this frontier land between academia and industry these new semi-autonomous organizations have emerged, constructed to act as mediators between academia and industry. (Nowotny et al. 2001, Braun 1993, Hackmann 2000, Guston 2001). These research institutions generally operate in the field of applicable research. An

introductory to this area will be given below and section 5.1.4 will go through these institutions thoroughly.

On micro level the attention on policy is drawn away. At this level one finds the individual actors in the knowledge production system. Actors for who research to a certain extent, is not about policy. The mentioned structural changes in science, has certain epistemic implications that continues to change the grounds on which scientists base their work. Changing the fundamental principles for the conduct of science is a distressing factor influencing most scientists. Whenever the focal point of doing research is becoming influenced by science policy and management the individual researcher face huge changes. These have to be incorporated in the working methods of the individual researcher.

1.5 Problem clarification

As noted from both the introduction and the problem identification social and technological changes are accompanied by a seductive rhetoric of permanent progress, creating the feeling that if one does not constantly renew oneself, one is hopelessly backward. Yet, history and tradition still counts and not everything moves fast. Not only opting one-sided for progress will break the code of change, additionally to use the tensions between innovative changes and tradition might also be a key factor in increasing the quality of future society.

As indicated above this thesis tries to embrace problems in somewhat different spheres, both in institutional and industry settings, science policy, innovation and society. The acceleration in European societal evolution has created novel questions that are to be answered by the correct functioning of the involved actors: institutions, industry and policy makers. Not only is it necessary for the individual actors to satisfy and function in accordance to new strategic goals and

constraints set forth by both management and public expectation, but at the same time actors have to cooperate with other spheres.

At this moment it seems quite evident, that the circumstances facing both universities, industry and policy makers is an extremely coded and complex situation in which to function, cooperate and govern. The actors have, not only, to comply with own strategic goals but at the same time, they face situations where decisions taken by their cooperatives in the knowledge sector impose huge gaps of asymmetric information.

Lots of literature has tried to define the environment characterizing the new production of knowledge. These theoretical contributions have offered a valuable understanding of the knowledge producing sector and furthermore given a schematic picture of the relevant actors and decision makers. Yet, country dependent characteristics influence and change the importance and existence of relevant actors. To bring the theoretical contributions to work in Denmark a thorough analysis of the specific Danish context is important.

Moreover, a common feature of the theoretical contributions has been to describe status quo for the relevant actors, without judging or comparing the success and scope of one institutional setting to another. This thesis will try to analyze and compare the scope and functioning of different archetypal knowledge producers and a university-industry spin-off. This comparison is needed as to be able to catch possible differences due to institutional size and whether this factor is determining the success of an industry engaging in a university-industry relation. Special attention will be paid at identifying specific Danish features of the knowledge producing sector - especially towards the actors and the functioning of the Danish innovation system and the influence of Danish industrial composition on the outcome and level of research collaboration.

Hence, the overall analysis of this assignment will answer the following questions:

What constitutes the Danish system of innovation and which factors influence knowledge producing institutions or organizations engaging in research collaboration?

What role does boundary organisations and industrial composition play in relation to university-industry research collaboration and to the overall innovative and entrepreneurial performance in Denmark?

To conduct the analysis, the following questions will be approached in a Danish context:

- How do science, technology, and innovation actually interact?
- Who are the actors or subset of actors in the Danish system of knowledge production?
- What role does Governmental research institutions and small- and medium-sized enterprises (SME¹²) play in relation to university-industry relations and to the overall innovative and entrepreneurial performance in Denmark?
- What are the processes of research collaboration?
- How can these processes be managed and steered and how can one make use of them?
- What is the role of policy in science?
- Are there certain attributes that are especially fruitful when engaging in research collaboration?
- Does institutional/organizational size matter?

The objectives will be:

- To examine the relations between science, society and industry.

¹² According to OECD the definition of SMEs are non-subsidary, independent firms which employ less than a given number of employees. This number varies across countries. The most frequent upper limit designating an SME is 250 employees, as in the EU. However the United States considers SMEs to include firms with fewer than 500 employees.
Source: OECD SME Outlook 2000.

-
- To identify important characteristics of the different spheres.
 - To analyze the practice of different Danish institutional settings as to constitute an analysis shading light on the possible strategic behaviour leading to fruitful engagement in the university-industry area.
 - To create an enhanced insight and transparency in specific Danish issues.
 - To determine the role of industrial composition and the innovation system on the level of collaborative efforts.
 - To contribute towards an understanding of the complex (and often uncertain) relationship between science policies and their downstream effects on scientific activities.
 - To make recommendations on implications for future collaborative efforts.
 - To determine the need for further research on key areas related to this subject.

These questions make up the guiding structure throughout this thesis. As aforementioned, the overall aim of the thesis is the analysis of university-industry relations and their connection to society with special focus on the specific Danish institutional size and setting.

1.6 Demarcations

Due to the magnitude of the problem formulation and the scope of this thesis, some demarcations are called for, as to ensure a concise and in-depth analysis of the research areas proposed above.

The area of knowledge production and collaboration has attained lots attention from many different angles, especially by social scientist and other studies of science. As a result the theoretical boundaries of this subject are very wide. In this thesis I have chosen to cover the areas of science policy and the investigation of university-industry relations in the context of the Danish research framework. An in-depth comparative analysis of the theoretical contributions will not be given. Yet the

development of a model, grounded on contemporary literature, specifically grasping the characteristics of the knowledge producing sector in Denmark will attain high priority.

The thesis will not look into the possible changes in the concept of knowledge and thus not into formulating new possible criteria for the assessment of knowledge. Moreover it will refrain from concluding on specific micro level issues concerning both managerial possibilities in research management and the creation of environments in which 'mode 2' knowledge production can flourish.

As knowledge production and the capitalization of knowledge are part of the innovation process the research area is closely connected to the functioning of regional and national capital structures – both private and public. As to set reasonable boundaries for the thesis, external funding and the functioning of capital markets – whether private or public – will be kept out as parameter.

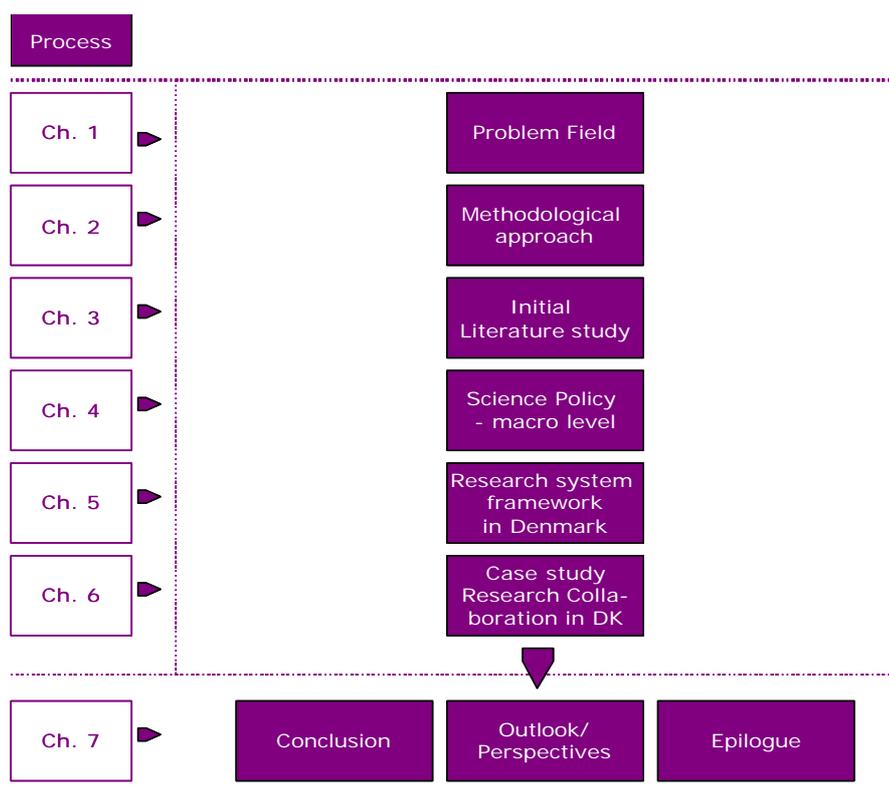
Choosing an exploratory approach moreover means that the overall aim of this thesis is to collect indications from a diverse set of actors in the Danish innovation system and present these in a university-industry-society perspective. Furthermore to provide with an identification of emergent barriers and areas that need to be investigated comprehensively in a Danish context. Thus, the thesis will cease from listing policy initiatives that the author finds urgent to be undertaken. Priority is given towards presenting the many methods and agents that can be used to steer this complex area of university-industry relations.

1.7 The structure of the thesis

To ensure a leitmotif through the thesis it has been divided in 7 distinct chapters. The introduction has now provided a general introduction to the central research questions of this thesis, and hopefully given an overview of the historical landmarks of the

development of public-private research collaboration and science policy. The problem identification is firstly meant to describe both the changes in the way research and science are conducted today, secondly the implications of this development in relation to research and market perspectives and thirdly the core agenda of this thesis.

Thus presented below is an informal model of the structure of the following chapters.



Figur 1.3 – Structure of thesis¹³

Before entering the journey of research and analytical work I need to determine the most suitable methodology and research design according to the empirical objectives presented in the problem clarification. Chapter 2 outlines the selection of methodological approach and the knowledge production process that is needed to obtain empirical data for the thesis.

Having presented the assumptions and limitations for this thesis, chapter 3 will continue on the basis of the opening and form a much

¹³ Source: Own production

more in-depth study of the theoretical contributions in this field. The focus is on understanding the structures, incentives and processes in public-private research collaboration. The theoretical contributions are dealt with synoptically rather than comparatively as to reveal the differences rather than to judge the reach or scope of them.

As to create a solid foundation for the understanding of macro level issues concerning science policy, chapter 4 will take a historical perspective in explaining the development of science policy, its scope and the preconditions attached to this policy area. Using a principal – agent model helps to define the nature of science policy, actors involved and the problems of ensuring the correct allocation of resources. Moreover, constructing a suitable actor-model that grasps the complexity of parties in the research area in that context is important. An analysis and description of this normative framework in which the knowledge producers make their decisions is central in this chapter.

Building on the model developed in chapter 4, chapter 5 will provide an overview of the Danish knowledge producing sector. The aim is to create a constructive and practical picture of the actors in the university-industry-society sphere, explaining the characteristics of the different subgroups and giving a complete picture of the Danish innovation system.

The empirical studies of this thesis are found in chapter 6. A case study on knowledge production and research collaboration is the core of this empirical study. Drawing on a qualitative study of four archetypal institutional settings (university, Science Park, Governmental Research Institution and a private research department) and one science based SME, the scenario model is constructed. The scenario approach explores not only the most plausible, yet also the most unlikely outcomes. Through a combination of the scenario approach, theoretical sources and recent statistics this chapter will indicate the most credible and possible outcome of research collaboration in Denmark. Moreover, I

hope to pinpoint the certain aggregated differences between the mentioned institutions.

Chapter 7 will be the final concluding chapter. Thinking the research results into a broader perspective will be the aim of this chapter, as to be able to present the complexity of tools and agents that can be used to steer and position research collaboration in the future. As an add-on these perspectives will be discussed in order to suggest possible new research topics in the following epilogue.

2. Methodology

2.1 Methodological approach

In the preceding chapters I've already indicated the trans-national, -institutional and –disciplinary aspects of the research topics in this thesis. In that context, it's noteworthy that this thesis will only deal with the problems in a Danish framework. Hereby not said, that the conclusions of the thesis would not be applicable or possible to implement in another national context.

The research topics of this thesis will be dealt with from both a theoretical and an empirical perspective and the basic guideline will be the problems formulated in the problem clarification above. In order to secure the most thorough analysis of the empirical objectives presented in problem clarification, a determination of the most suitable methodology and research design is called for.

The empirical analysis is based on qualitative research interviews with 5 chosen research institutions. The choice of a qualitative method primarily implicates the use of an exploratory rather than an explanatory knowledge production (Andersen 1997). Furthermore the collection of qualitative data is specifically chosen as to comply with personal and economic factors.

As to cover the whole range of both public and private research institutions the interviews will concentrate on representatives from each of the following archetypal groups, constituting a multi-case approach:

- Universities
- Science parks
- Sector research institutions
- Private research departments
- Science based SME

The analysis will be based on interviews with representatives from the selected institutions – 1 manager and one floor-researcher pr. institution respectively – concerning their views on public-private

research collaboration. An interview guide is constructed, to form the basis of revealing the interviewees perception of the institutional settings in which they work and to evaluate this environment in a university-industry collaborative perspective. Moreover the interview guide serves the purpose of keeping the author focused on the relation to the problem formulation. The research design is therefore designed as exploratory – characterized by the process of moving from empiric data (individual answers) towards a generalization of common knowledge (Andersen 1997) – and furthermore as an inductive conclusion. The interview guide is constructed as a semi-structured analysis with open-ended questions covering 6 overall subjects.

The interviews were conducted during the winter of 2001/02. The sample contains 10 individual interviews that were tape-recorded and transcribed. The interviews lasted approximately 1 hour. Except for three, all the interviews were conducted in Danish, and quotes from these appear, without mentioning the originator, from time to time during the thesis in my own translation.

2.1.1 Qualitative analysis – pitfalls and problem areas

The debate on the use of either qualitative or quantitative data is a history of trench warfare (Andersen 1997) - and certainly there exist limitations to the use of both methods. The most conspicuous problem area when using a qualitative approach is the fact that the interviewer has to be very open-minded when analysing and interpreting the interviewees' answers. This problem area arises not only because of different frame of reference, in which situations words can mean very different things. Even in the same language people can mean very different things by the same word. In the event of the same frame of reference the problem likely becomes cognitive understanding, making it possible for the interviewee to deduct the 'right' answers from the question. As to limit this problem it's been an important task formulating questions as objectively and clearly as possible.

According to Argyris (1997), the concepts of 'theory-in-use' and espoused 'theory-in-action' and furthermore the concept of inhibitory loops explains the behaviour of humans in relation to encoding and interpretation. What Argyris points out, is the difference between an individual's, theory-in-use and espoused 'theory-in-action' leading to behaviour constantly characterized with inconsistency. Continuing with 'inhibitory loops' they, very briefly, characterize the situation where individuals talk at cross purposes, increasing the individuals unsaid assumptions about the other individual. In that scenario, a conversation enters an inhibitory loop – leading to mistakes and ambiguity (Argyris 1997)¹⁴.

The social constructivist approach deals with the problems and uncertainties evolving when doing qualitative research. It's emphasized that one should expose the uncertainties to consideration and discussion and moreover that the researcher continuously reflect on ones own influence, thus being aware on the consequences his/her behaviour may have on the interpretations made. During the work with this thesis I've tried to comply with these difficult guidelines as to secure the best result possible – and the end goal has been to achieve the highest level of validity and reliability.

The process of maintaining focus during the methodological approach has mostly been characterized with taking field notes, transcribing, coding, memorizing and keeping a reflective journal as to keep track of the different comparisons between instances in the empirical data collected and of the different actors in my analysis.

Before heading out on a journey and beginning a knowledge production process, it is important firstly to elaborate on the scope and breadth of the thesis opposed to other literature on the subject,

¹⁴ The factors leading to the 'inhibitory loop' are denoted 'conditions of error' (Argyris 1997)

secondly to consider the implications of the above description of the 'new production of knowledge'.

2.2 New strategic and theoretical perspectives

This thesis tries to embrace the subject of university-industry relations in a Danish context. The method chosen tries to take up certain problem areas that the author hasn't been able to find in contemporary literature that consider Denmark as a case. It's not the purpose of this thesis to break out from the general and well-described theoretical contributions in this field, but to add a new perspective in analyzing the relationship between the actors in the knowledge producing sector. Therefore the thesis tries to investigate the specificity of recent models on university-industry relations and thus tries to augment these models as to gain enhanced insight and transparency in the knowledge producing sector. As a particular Danish feature this thesis focuses on the role of specific actors in the Danish knowledge producing sector – hereby looking further into the role of boundary organizations (government research institutions) and of small- and medium-sized enterprises (SME) in relation to university-industry relations and to overall innovative and entrepreneurial performance in Denmark.

2.3 Knowledge production – contemporary perspectives and implications

Writing a thesis concerning the implications of a 'new production of knowledge' and its significance in a collaborative perspective between science and society actually gives rise to some pretty peculiar considerations. The characteristics of the 'new production of knowledge', as exerted by the contributors in this field of research sets new standards and forms a new constitution of science, that has to be internalized in ones own study.

Now is not the time to judge whether this thesis, complies with either basic or applied goals in science – time will tell. But what is on the agenda at this point is ensure compliance with the new theoretical perspectives inherited in e.g. ‘mode 2’ knowledge production - the dynamic, interdisciplinary, team-based form of knowledge creation (Gibbons et al 1994, Nowotny et al 2001), as opposed to mode 1 which is characterized as an expert, discipline-bound, free of commercial interest and self-referential mode of knowledge production. In very short terms an institutional shift from mode 1 to mode 2 is pinpointed by Gibbons et al 1994¹⁵. This shift is a natural answer to the problems of applying scientific knowledge in non-scientific and commercial contexts.

Expanding the description of mode 2 as to pinpoint the perspectives for the author of this thesis, brings about the following characteristics as formulated by Nowotny et al (2001) in their book ‘Re-thinking science - knowledge and the public in an age of uncertainty’.

- **Contextualization**

The pivotal point in the transformation of science is the movement towards applicable research. Thus, knowledge production is affected by a reversal of the relationship between society and science – instead of only science changing society; society is now playing an important role in changing science, which fundamentally is what is meant by contextualization. Bringing a ‘public eye’ into play in science, satisfies both end users, helps defining new scientific problem areas and penetrates the epistemological core. As a further result, the contextualization redefines the reliability of knowledge making it socially robust (Nowotny et al 2001)¹⁶.

¹⁵ Please refer to chapter 3 where these concepts are treated more thoroughly.

¹⁶ Socially robust knowledge has three distinct features: 1. Valid both in- and outside the laboratory (in science and society), 2. Validity is secured by involving an extended group of experts, and 3. As society has participated in the production of knowledge, it's less likely to be contested. (Gibbons 1999)

- **Scientific communities – cross-boundary research teams**

The proliferation of research networks, teamwork, global electronic communication and other collaborative forces are the 'raison d'être' for the increasing accumulation of knowledge and technique. Thus, the notion of scientific researchers working alone is obsolete in contemporary science. The progression towards more complex scientific problems implies that individuals working independently cannot solve these problems.

- **Agora**

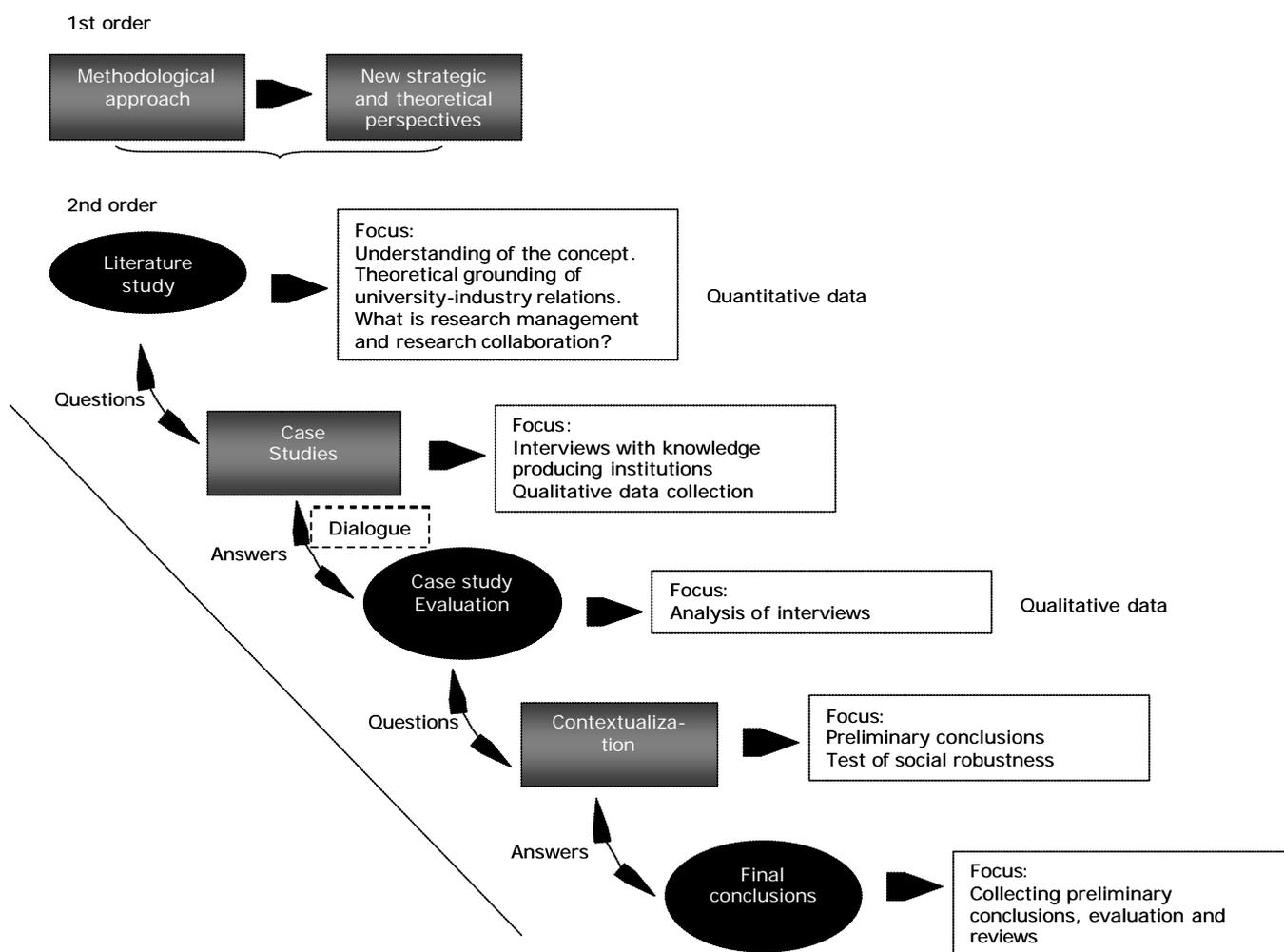
The epistemological core of science has over time been under influence of norms and practices, which cannot be reduced to one generic methodology.

Science has moved out of the former institutional locations in government, industry and universities into the 'agora' (Nowotny et al 2001) – the public space where interaction between science and public happens as a dual process, science meets the public eye and public 'speaks back' to science. The concept of the agora is much connected to the process of contextualisation - in the sense that knowledge is presented in the agora as a way of contextualisation, whereby the notion of robustness arises. Letting all different kinds of interested parties look into the knowledge produced supplies the producer with important evaluation and review.

As noted from the above and the characteristics presented in chapter 1.3 it's underlined that a melting together of scientists, stakeholders, citizens etc. is happening in order to satisfy both public and private expectations of science – aims of socially accountable, applicable and robust knowledge production

Taking elements of this new framework of knowledge production into account, it is essential to build a research methodology that

corresponds to this process. Below I've constructed the framework for a methodology comprising the specifications given in the theory of 'mode 2'.



Figur 2.1: The knowledge production process during the thesis¹⁷

The primary objective has been to enforce the use of a dual-process waterfall model – constantly securing a contextualization of knowledge, forming the best possible foundation for the further production of new knowledge. This cycle secures feedback from the agora before setting out on new endeavours. Questions are formed on the basis of socially

¹⁷ Source: own production, inspiration comes from informal discussions with Christian Vintergaard on the scope of 'mode 2' knowledge production and its influence on ones own research process.

robust knowledge while answers are sought through new information and analysis.

As clarified in the problem identification and the problem clarification, the objective of this thesis is to make an in-depth analysis of university-industry relations. The analysis is a multiple case-study¹⁸ (Andersen, 1997), where the intention is to produce a method for describing university-industry relations with special emphasis on collaborative aspects in the production of knowledge. In order to clarify the questions stated in the problem formulation, material from qualitative and quantitative sources have been collected. The information needed about university-industry relations as to form a theoretical foundation was quantifiable whereas information about the specific Danish framework and environment for university-industry relations was collected using interviews (qualitative data).

The following short paragraphs will elaborate on each of the steps made in the model.

2.3.1 Literature Study

In order to create a solid base on which to both investigate theoretical and practical issues and to build new ones, a broad literature scan has been conducted. The focus has been to map the overall boundaries in this area and to obtain understanding of the most conspicuous problems. In the wake of the literature study, it became evident that there were both theoretical and practical problems in a Danish context that needed further investigation

¹⁸ A selection of series of cases for analysis (as opposed to a single case-study)

2.3.2 Case studies

Formed on the basis of knowledge collected in the literature scan, 5 distinct cases were chosen. The aim of presenting these cases has been to illustrate different methods and working practices and to establish links from theory on to practice.

Case selection:

As pinpointed in the methodological considerations of this thesis, chapter 2, the cases have been chosen to be able to exemplify specific objects and to make it possible to draw generalized information from the cases and hereby understanding the theoretical contributions rather than explaining these. Moreover the case studies have engaged the author in a learning process that couldn't be reached through theoretical studies alone.

As to be able to choose good cases, setting up some criteria to choose from were called for. In a Danish context the following archetypical knowledge intensive institutions were identified: 1. universities, 2. science Parks, 3. large science-based industry and 4. governmental research institutions. The categories were made, not to form a preliminary typology of different research institutions, but to be able to draw out the most generalized information from these large-scale cases. The above mentioned categories constituted the first four cases. In order to investigate the differences in institutional setting between the four, and to be able to form a large-small scale comparison the object of choosing the fifth case, was to present a new case in a Danish context that operated in the field between university and industry. The focus was to choose a case with a different institutional setting and size and therefore choosing a science-based small- and medium-sized company seemed plausible.

Constructing the interview

The construction of the interview guide was founded on the literature study. Most questions have their heritage in current literature while others are formed on problems raised in alternative sources, e.g. the media. As noted in chapter 2.1, the formulation of questions had to consider the aspects of same frame of reference and furthermore the problem maintaining the objectivity of the interviewer. Concerning the construction of the interview guide several other aspects were considered. The focus was on the construction of both overall categories to be covered and specific questions in these categories. It was not the intent in the research design to follow the specific questions in a strict manner in accordance to both order and formulation. Rather the questions should give the author the opportunity to both secure the overview and at the same time to improvise and follow some of the leads in the interviewees answers. All the questions proposed in the interview guide have been considered with regards to 'relevance to theme' and 'relevance to dynamics' of the interview (Kvale 2000). Considering 'relevance to theme' the questions were constructed as to relate to the subject of the thesis and the theoretical contributions on which it is based. In a dynamic context the focus in the interview situation has been to create a positive interaction and to keep the conversation fluid.

2.3.3 Case study evaluation

In order to preserve most information from the different interviews a recording device was used. All interviews were transcribed afterwards and compared to short notes taken by the interviewer during the interview. The transcription of the interviews was not literal. Due to the fact that the interviews main purpose was to reveal common impressions of the interviewees' points of view it seemed reasonable for the author to leave out repetitions, and in most parts of the interviews

to summarize and condense the spoken word. In some parts, where the interviewee expressed unexpected or interesting points, the transcription has been literal.

All interviews have been conducted as separate sessions allowing for evaluation in between and interview guides and summaries are included in exhibit 1 and 2 to 12. During this process it has been possible to compare statements of one interviewee to another and to test these.

Due to the interviewees' different frame of reference and interest some of interviews differed from the overall categories and questions – both by leaving out questions in some categories and by intensifying questions in other. This was necessary in obtaining a dynamic session and represented a difficult continuous evaluation during the interview – resulting in possible subjectivity. It has still been the aim of the author to stay as objective as possible and under these circumstances to ensure the highest level of both validity and reliability in respect to the problem clarification (Kvale 2000).

2.3.4 Contextualisation and final conclusions

In order to comply with the objectives of contemporary knowledge production as described in chapter 2.3 the interaction in the agora is an essential part of testing ones findings and conclusions. As to provide the most complete picture of the findings in this thesis, interaction with colleagues, fellow students and other parts has happened as a continuous event while writing the thesis.

The feedback from the interaction process from above was incorporated in the final conclusion and the epilogue. Interaction in the agora has provided both feedback and new perspectives to the author. Revealing new perspectives have certainly made it an interesting task to write the epilogue and to form what could be the research agenda after this thesis.

3. Literature study

3.1 Introduction

In trying to understand modern society and its structures, many social scientists have concentrated on investigating society's dynamic characteristics. The increased focus on scientific and technological conquest as socio-economic drivers has gained greater interest from the public in the light of securing a high standard of welfare. With this enlarged focus, the need for accountable and socially responsible and justified knowledge production transpires.

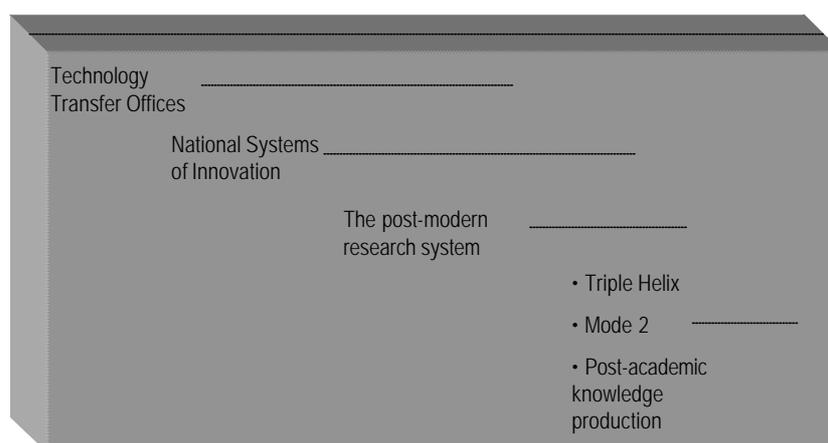
A wide range of theoretical contributions in the social sciences have been shaping the area of research collaboration, science policy and knowledge. In a historical perspective the research area in the social sciences concerning the transitional tendencies in research collaboration, science policy and knowledge production has developed a long range of models, each being prevalent in a period of time. These different models will be covered in the next paragraph.

3.2 The nature of research activity

As noted in the opening the widely acknowledged effect of the linear model and its prescriptions for a sustainable welfare system prevailed during the post-war period. But the decentralization of research to a larger and more diverse group of knowledge producers has fostered a development of both normative and cognitive change. First and foremost the growing number of researchers involved in knowledge production creates certain competitive aspects. A growing number of researchers interested in getting a share of the funding available logically create harder competition, but also a need to look elsewhere for funding. This diversification of funding, especially from industrial firms, is an important factor in the coupling of research and technological innovation. Another critical feature of the emergence of

the contemporary 'knowledge society' is the rise of a new type of knowledge creation, as noted earlier.

Taking a chronological perspective¹⁹, a pattern of evolution in the nature of research and the science-society linkage can be seen as indicated by the timeline below.



Figur 3.1: Overview on theoretical contributions in the science-society field²⁰.

As can be seen from the figure a variety of perspectives in understanding the changes in research and innovations systems exist. These perspectives operate with each of their own variables, trying to provide a steady-state picture of a very dynamic area. When looking at a very dynamic area it will be very difficult to appreciate its features as to provide a static picture.

Below will be given a very brief description of the three strands. These represent typifications of the different institutional settings and policy models in the relation to research collaboration. Henceforward, focusing on the most contemporary models, the three very important contributions of Gibbons et al (1994) and Nowotny et al (2001) in

¹⁹ By chronological, the author wishes to indicate a loosely evolutionary pattern of theories in the science-society area. The aim is absolutely not to assign specific theories to specific periods of time, as the different theories coexist with different momentum, but rather to indicate the very broad lines in which the theoretical contributions have had the greatest impact.

²⁰ Source: Own production.

section 3.2.1, Etzkowitz and Leydesdorf (1995) in section 3.2.2 and Ziman (1994 and 2001) in section 3.2.3.

Technology Transfer

In the academic world, the concept of Technology Transfer Offices (TTO) evolved, and these offices arose as intermediaries, promoting academic basic research to industry and society (Etzkowitz 1998). The underlying conception of the innovation process that drove technology transfer seemed to be the linear model as described earlier. This type of arrangement involved payment for services provided by the university – either as consultancy hours or as endowments. Moreover, the concept of TTO enabled a framework, in which the transmission of knowledge between university and industry could take place, without influencing their classical functions and overstepping their well-defended boundaries (Etzkowitz 1998, Siegel et al 2001). The technology transfer approach is still a commonplace approach although new and more dynamic forms of relationships have evolved, as the linear model of innovation is an unsatisfactory description of the innovation process.

National systems of innovation (NSI)

During the 80'es the concept of national systems of innovation arose by the work of Freeman (1988), Nelson (1988) and Lundvall (1988), and set forth a framework allowing for a systems approach in understanding the possibilities and opportunities in innovation (Lundvall 1992 & 2000). It points to the fact that the process of innovation is evolutionary and therefore not directly can be linked with optimality.

A key factor in this approach is assigning firms with the highest innovative capacity and leaving the variable of governance or policy out of the picture. The characteristics of a national system of innovation (NSI) can be summarized as:

- Firms are part of a network of public and private sector institutions whose activities and interactions initiate, import, modify and diffuse new technologies.
- An NSI consists of linkages (both formal and informal) between institutions.
- An NSI includes flows of intellectual resources between institutions.
- Firms don't normally innovate in isolation but in interaction with other organizations in their network

3.2.1 Mode 2

It has been argued that science is entering 'Mode 2' (Gibbons et al., 1994) superseding the traditional mode of science referred to as 'mode 1' described earlier in chapter 1.2. The major feature of this new mode is the negotiated character of knowledge production: marketable knowledge is produced through a process of continuous negotiation of needs, interests and specifications of all the involved actors. The Mode 2 is brought about by simultaneous expansion of knowledge producers on the supply side and the expansion of the requirements for specialized knowledge on the demand side.

| Mode 1 | Mode 2 |
|--|---|
| Problems set and solved in a context governed by academic community. | Knowledge created in the context of application. |
| Disciplinarity | Transdisciplinarity |
| Homogeneity of producers | Heterogeneity of producers, encouraged by ICT. |
| Hierarchical and continuing | Heterarchical and transient |
| Quality control through peer review. | Socially and economically accountable reflexive quality control |
| Emphasis on individual creativity | Emphasis on collective creativity |

Figure 3.2: Mode 1 and 2 comparison²¹

²¹ Source: Own production

Unlike the traditional mode 1, knowledge is now produced in the context of application, and the differences between curiosity-oriented and mission-oriented research are softened. The figure above denotes some of the differences in going from mode 1 towards mode 2. It is noted that these processes are only taking place within specific scientific disciplines while much of the rest of academic science continues to operate in the traditional mode. Secondly, the concept of the 'knowledge economy' points to the fact that the modern economies are directly based on the production, distribution and use of knowledge and information (OECD 1996). A related concept is the 'learning economy' that signifies a society where the capability to learn is critical to economic success. As primary producers of basic science the transition from basic to applicable research means that the universities will constitute a less dominant role in the knowledge producing sector (Gibbons 1994, 2000).

3.2.2 Post-academic knowledge production

The concept of post-academic knowledge production is taken from Ziman's (1994, 2001) description of the changing aspects of knowledge production, dissemination and use. Ziman follows the same observations as Gibbons, and describes a picture of modern science containing more management, evaluation and greater focus on application and inter-disciplinarity. An increasing degree of collectivization is the answer to the rising complexity of research problems and the increasing possibilities to work together across institutional and disciplinary boundaries. Scientific problems are defined by large groups and constellations of researchers and other actors within and beyond the academic system rather than by single researchers. Research is thus no longer a self-governing isolate. Contemporary research in medicine, technology and the sciences (but also in other areas) is centered around the research group. The utility

aspect has penetrated science and the mentalities of researchers and become a driving force as important as scientific reputation.

An important post-academic innovation is the large-scale, planned research project. In itself, the project means that a plan for the organization of research (preferably also its results) is presented before the research is begun, to be evaluated by committees, which often consider aspects of utility and usefulness. This has most likely contributed to an increasing efficiency of academic research, but has also limited the freedom of scientists to choose their methods. Academic freedom is conditioned; everything is no longer possible but all proposals must pass through different evaluation processes before research can begin. As a result of these developments, life in the post-academic system is regulated by bureaucratic rules. It reflects the fact that the academic isolation from the norms of the surrounding society has been broken.

According to Ziman, the object of analysis is not how we manage to avoid this transition, but in stead how we make the most out of all the new opportunities following in the wake of organizational, political, intellectual and social change.

3.2.3 Triple Helix

Lastly, H. Etzkowitz and L. Leydesdorff have analyzed the interdependence, or 'Triple Helix' of three internal dynamics: that of knowledge production, the dynamics of industrial development and government policy formation (Etzkowitz and Leydesdorff 1996).

Building on recent models of research collaboration the Triple Helix models identifies policy or governance as an important factor in research collaboration.

In a university context, the triple helix perspective proposes a prominent role for the university as primary knowledge producers. In the model, basic research will be linked to application through a series

of processes and there will be an increasing utilisation of basic research. The increase in the use of basic research in the context of application naturally imposes change in the concept of basic research and this eventually mean, that basic research in a traditional sense, will have a far less prominent role in the future (Etzkowitz 1998).

Assigning universities with a prominent role as knowledge producers is quite different from the NSI-approach which assigned firms with the highest innovative capacity. In comparison with mode 2 knowledge production, the triple helix also focuses on the dynamic of collaboration and negotiation between many actors in the knowledge producing sector.

To summarize the trends captured by the above concepts, it can be said that the growing share of scientific knowledge is produced in the context of application and converted into intellectual property that is traded in the market like other economic goods are. Scientists are increasingly engaged in market activities like other professionals and entrepreneurs. While these processes are stipulated by the internal dynamics of the major developed economies, in which knowledge and learning become the key resources, they are also actively promoted by the state encouraging commercialisation of science through a decrease in direct funding of science and education and creating incentives for closer university-industry linkages and greater involvement of scientists in market and market-like activities. These processes represent a move towards market values in the production of knowledge and moreover a discourse of accountability (Delanty 2001).

Furthermore there's a clear focus on research management, trying to solve some of the obstacles when engaging in new production of knowledge. The research agenda in research management has to cover both sides of the coin: the fact that industry at the same time wants to

build hierarchies and networks and the fact that universities have to cover both scholarly quality and relevance in society.

4. Science Policy – macro-level perspective

In an increasingly complex society, local and national authorities often feel the need to rebalance between steering and autonomy. Taken together, new forms of uncertainties have been added to the political agenda. Upon the decision-maker rests the task to nevertheless at least try to look into the future. Referring to the earlier characterization of both Smith and Polanyi, the self-regulation of markets and economies are a precondition for the preservation of democratic political systems. The democratic values are among the most valued by the public, hence interfering with the autonomy and functioning of the socio-political subsystems is a major challenge (Ziman 2001, Guston 2000). Applying this subsystem approach, e.g. industry, politics and science can be seen as subsystems. In trying to couple these subsystems in a systematic yet autonomous way, they as a natural consequence become objects of regulation. This is one of the most important issues when working with the integration and acceptance of policy, more specifically science and technology policy (S&T policy) (Guston 2000, Stokes 1997, Gibbons et. al 1994, Rip and Van der Meulen 2001).

4.1 Science policy allocation process – framework and actors

The need of more advanced analysis of the complex relationships forging the future has been an important factor shaping the field of science, technology, and innovation studies in every advanced industrial country (Grande 1998). Science policy generally involves the problems of choice, patronage and control. These three factors, especially the use of state patronage in science has inevitably brought science into politics and politics into science – and by accepting state funding on a large scale the scientific system is in a situation where it's very exposed to the demands of the state. Hence, a system of asymmetric information has evolved between the patrons of research and the recipients of

funding. The patrons are not entirely sure that the recipients are doing as planned and the recipients are having a hard time proving that they're following the right track.

Instead of taking the perspective of 'how much' in relation to science policy one should instead consider question of 'how'. Indicated by the term of inter-organizational networks, the bringing together of actors from the relevant subsystems have become a characteristic feature of S&T policy on a national level.

4.1.1 S&T policy in a principal-agent perspective

The bringing together of different subsystems in the event of collaboration gives rise to a range of problems. A great factor in collaborative processes, especially in the collaboration between state and science, is the problem of 'asymmetric information'. To investigate the 'game' between the above mentioned actors it seems fairly reasonable to draw on the theory of principal-agent relationships. A principal-agent relationship basically emerges whenever one individual depends on the action of another (Guston 2000, Braun 1993). The theory originally arises in a business management context associated with behavioural studies of employer-contractor or employer-employee interactions but it can reasonably be applied to public and non-profit settings as well (Guston 2000, Braun 1993). In the following description it's therefore possible to substitute principal with policymaker and agent with the scientific community.

From the perspective of the principal-agent the central dilemma investigated by principal-agent theorists is how to get the employee or contractor (agent) to act in the best interests of the employer (the principal) when the employee or contractor has an informational advantage over the principal and has different interests from the principal. Agency costs are a type of transaction cost, reflecting the fact that without cost, it is impossible for principals to ensure agents will act in the principals' interest. Agency costs include the costs of

investigating and selecting appropriate agents, gaining information to set performance standards, monitoring agents, bonding payments by the agents, and residual losses.

The relationship of state and the scientific community is the most abstract in S&T policy as there's no single principal or agent. But the aggregation of the two still points out the problematic relationship. The existence of asymmetric information, as investigated in much micro-economic literature produces two very important factors, 'moral hazard' and 'adverse selection'. Moral hazard describes the occurrence of 'fraudulent' action undertaken by the agent. It's difficult for the principal to monitor the agent and to ensure the agent will continue to follow his delegations. Adverse selection describes the lack of information possessed by the principal to secure the most efficient choice of agent (Guston 2000). In other words the two characteristics describe, firstly a problem of hidden behaviour, and secondly of hidden information. No matter, the agent selected, problems ensuring the correct conduct of e.g. research still remains. Science policy therefore has to deal with the two facts:

1. How can the patron be sure that research is conducted with integrity?

2. How can the patron be sure that research is conducted with productivity?

In that respect, it's important to stress the fact that integrity and productivity are not fixed cognitive concepts, but their meaning vary over time – the change towards more applicable research is a very good example on the change in integrity. A very interesting point in relation to this flux is pinpointed by Guston (2000):

"It will remain in the durable interest of the principal to be concerned about the integrity and productivity of sponsored research"

So while the concepts of integrity and productivity remain in continuous change, the interest of the principal and moreover the interest of the

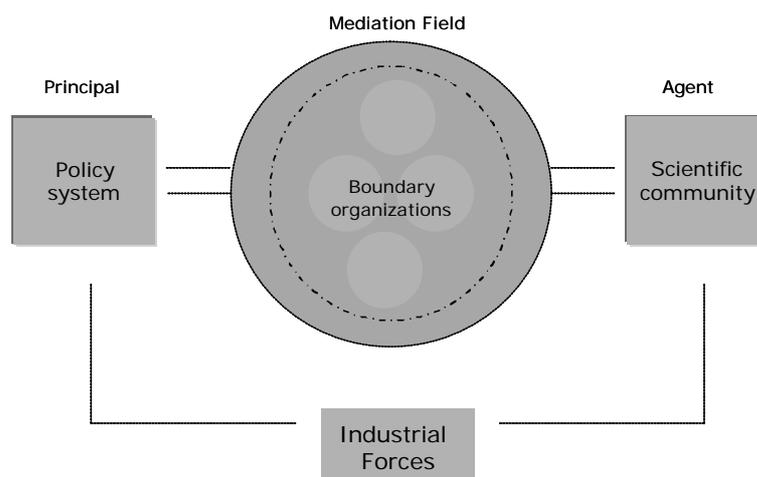
agent to be able to demonstrate integrity and productivity, remain fixed and durable.

4.1.2 Boundary organizations - augmenting the principal-agent model

The ways in which both actors, in this seemingly dyadic relationship, assure each other of integrity and productivity will not be covered here. But augmenting the principal-agent model according to Braun(1993) and Guston(2000) deals with some of the simplifications encountered when applying the principal-agent on an aggregated level. In aggregating the relationship between policymaker and scientific community one automatically underestimates the role of semi-public intermediary institutions (boundary organizations) emerging in the area between policy and academe. Likewise, the existence of industry interests in national S&T policy, affects the principal-agent game.

Boundary organizations are institutions that span the shifting divide between politics and science. They draw their incentives from and produce outputs for principals in both domains and thus, it is hypothesized, facilitate the transfer of useful knowledge between science and policy (Braun 1993, Guston 2001)

Braun originally expanded the dyadic relationship between principal and agent to embrace a third part – namely the boundary organisations. Yet as stated above the system is also under increasing influence from industry taking active interest in the formulation of S&T policy. Thus I will take the liberty of enhancing the triadic structure of policy system, mediation field and scientific community with the existence of industrial forces.



Figur 4.1 – Augmentation of principal-agent perspective²²

As noted from the above figure the functioning of the science political system is under increasing influence of a new type of organisations governing the mediation field. The boundary organizations represent a group of pro-active and more independent players influencing the relationship between principal and agent. The in-built logic in the science political field, as described in much literature on the subject i.e. Guston(2000), Stokes(1997), Ziman(2001) is a linear process of decisions, activities and outcomes. In a science-context this means a linear process where the aims of society are embraced by science policies that stake out the framework for the scientific community. This framework pinpoints the activities to pursue by the scientific community eventually leading to a scientific output in relevance to society.

But as argued in the rejection of the linear model of innovation earlier in this thesis, the proposed linearity between the processes in science policy is an over-simplistic view on reality – and this is where the boundary organisations come into play. The causality between decisions, activities and outcomes is not as unproblematic and simple as a 'left to right' movement. Rather than linear the science political

²² Source: Braun (1993), yet the augmentation with industrial forces is the authors own proposal.

allocation is characterized with a complex intertwined web of interactions between the actors and across spheres. As seen in the figure below, the boundary organisations can be characterized as both formal and informal entities and members of either a policy infrastructure or an institutional infrastructure.

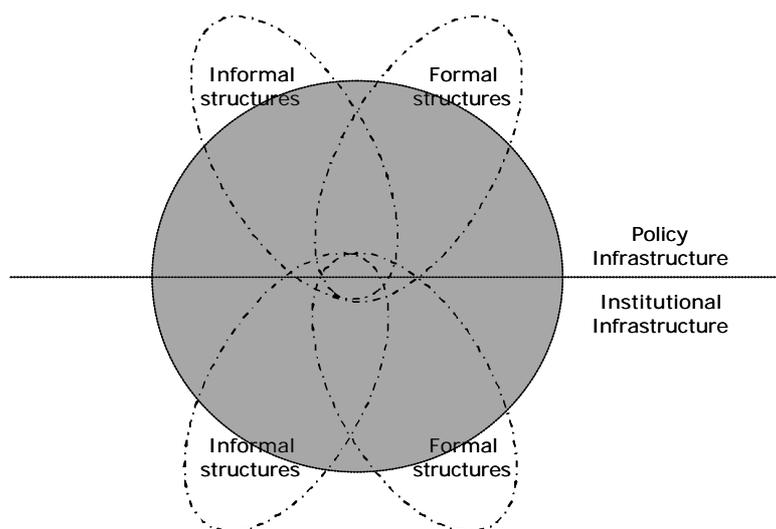


Figure 4.2: The mediation field between policy, academe and industry²³

Taking a closer look at the mediation field consequently reveals an even more complex picture than the original principal-agent perspective. By supplementing Braun's original triadic figure with both industrial forces, as above, and two infrastructural subsystems we get a more complete picture of the complexity – a quadrangular link structure of the knowledge producing sector and the 'room' in which policy-making is happening.

Yet, further enhancements are called for as to explain the underlying consequences of specific cultural and financial aspects that influences the actors in the model. By adding an 'under-layer' of "national innovation culture" the foundation on which the above model rest, is formed. The final model is seen below, a pentagonal system of actors or

²³ Source: own production, through conversations with Søren Wenneberg and Christian Vintergaard

subsystems in the knowledge production field, revealing large diversity in the institutions governing the mediation field – both within the subset of actors and between the different subsets. As noted, the model doesn't only grasp the different actors in the sector, it also illustrates the rising complexity and diversity in the dynamics of modern S&T policy. The divide between state and society has become infiltrated by other actors and policy resources are therefore much more actor- or context dependent. This distribution of policy resources onto both public and private actors means that instead of being centred, the policy-process has become networked involving several central actors whereby the principal actor has become eradicated (Hackmann 2001)

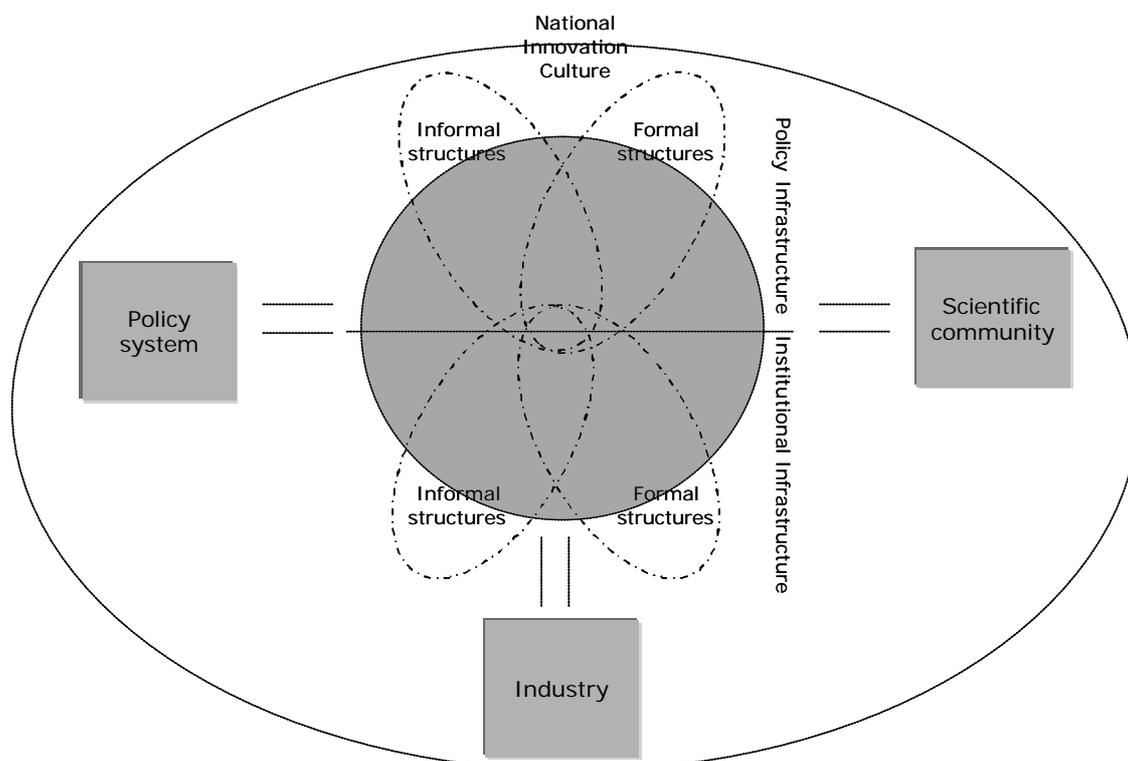


Figure 4.3: Contemporary innovation system – pentagonal linkage structure²⁴

²⁴ Source: own production, pentagonal referring to the following groups: policy system, industry, scientific community, mediation field and national innovation culture.

5. Linkages of the Danish research system

In order to be able to understand both political and theoretical implications for the new production of knowledge in a Danish context, it's important to investigate the development and characteristics of the Danish research system.

In the following paragraphs I will go through the essential characteristics and try to create an overview of the actors in the university-industry-society setup. This analysis will be based on the model developed throughout chapter 4, though explicitly pinpointing and mapping the individual actors and forces and their position in the model.

5.1 The Danish research system – groups of actors

Having the figure 4.3 in mind, it seems fairly easy to investigate what constitutes the scientific community. Yet complexity and foremost increasing diversity in the different subgroups eradicates what can be typified for example as the scientific community. Being under constant influence of many different actors, whose behaviour and self-perception is under continuous change adds to the blurring of the picture. Therefore, the description should be seen as a steady state picture of somewhat dynamic subgroups and individuals.

Before going into an analysis of the different actors, a characterization of some general trends in the research system, building on the theories used so far, is called for.

- **Intra- and inter-organizational collaboration between one or more actors in the framework**

With an expanding knowledge base and with resources widely dispersed – the times where innovation could happen within just a single person or company are over. Thus, more and more knowledge institutions engage in collaboration of different kinds.

Due to an increase in complexity the level of competencies

needed to stay in the market is increasing (Gibbons et. al 1994). This participation in collaborative arrangements and the central placement in knowledge networks are essential to create and follow innovative ideas. Innovation is seldom created in the periphery of a network – but more likely in the focal points where many actors interact (Powell 1996).

- **Combination of complementary assets**

Realizing that ideas new to the market or new to a company aren't generated solely by one organization, the strategic choice of pooling resources may prove to solve problems of rapid technological development and research breakthroughs. Research collaboration between public and private research, as well as across different industries (Gibbons et. al 2001) may be the answer to that.

Referring to earlier chapters universities are therefore taking responsibility in securing societal needs and goals (Gibbons et. al 1994, Etzkowitz 1996 and 1998, Nowotny et. al 2001).

5.1.1 Policy system

The policy system is more or less constituted by the Danish government, more specifically the Danish Ministry of Research and Information Technology and its associated Committees and Research councils which will be described shortly below. A description of the policy system would seem to be rather trivial, yet many factors contribute to the above mentioned blurring of the boundaries between the actors in the model. The blurring of the role of the policy system is augmented with the election of a new government in the fall 2001. Some important factors in that context are:

- Restructuring of the different ministries
 - The Ministry of Science, Technology and Innovation

Former *Ministry of Research and Information Technology* was created in November 2001 to comprise the universities (research and education), industrial research and Denmark's policy on technology and innovation.

The object of the Ministry is to promote the interaction of trade and industry, centers of research and education and to strengthen coordination in pursuance of industry and science policy.

- o The putting together of the former ministries of Business Affairs, Economic Affairs and parts of Housing and Urban Affairs yielding the Danish Ministry of Economic and Business Affairs.

Main focus is monitoring the Danish economy and preparation of the economic policy, legislation and surveillance of the financial sector, international economy and economic political cooperation within the EU.

- The issuing of the new Danish fiscal policy for the year 2002

A fiscal policy in which a long range of institutions – including some of the institutions mentioned below – are abolished to cut down expenses on a national level.

5.1.2 Industry

Considering the industrial sub-system in the model Danish industry has some important characteristics that should be mentioned. In relation to research and innovation it could be reasonable to consider research oriented firms as part of the scientific community. But to

maintain the unit of analysis I will treat them as part of the industrial sphere in this analysis.

First and foremost it should be kept in mind that the diversity and differences between the many different firms and industries cannot be fully covered but some very general characteristics can be mentioned.

- **Industrial composition**

The composition in Denmark is characterized by a very large number of small and medium-sized companies and very few large industries. In Denmark in 1996, SMEs accounted for almost 100% of firms (the share of large firms in the total amounted to 0.2%); very small firms (0-9 employees) represented 92% of the total (OECD 2000).

- **Research and Innovation**

The companies in Denmark are distributed among very diverse sectors, and the number of research oriented companies in each sector varies a lot. Yet, it seems quite indicative that the extent of research and innovation is proportional to firm size. The larger the firm, the more likely it is to be an innovator. In relation to sector, there also exists remarkable variation in the distribution of innovators between each sector. Biotech and chemical industry as well as the electrical and optical manufacturing industry present the largest proportion of innovators (EU Commission 2001).

- **Patents & expenditure on innovation**

The composition of the industry also affects the amount of money used on innovation and closely related to this, the number of patents applied for. Statistics show that firm size also matter in this area. Cross-European studies show that only 15% of small firm innovators applied for a patent compared to 28% of medium-sized and 51% of large ones.

Considering the expenditures on innovation, they encompass a long range of different activities: knowledge creation through R&D, processes of knowledge diffusion, absorption and appliance, investment in capital equipment etc. In this area large companies also dominate, spending almost twice as large a proportion of their turnover on such activities as do small ones (EU Commission 2001).

- **Collaboration**

Involvement in collaborative arrangements is part of the innovation possibilities at hand. Collaboration happens as partnership with enterprises within the same company group, upwards and downwards the value chain (suppliers and customers), universities or public research institutes. The rate of collaboration among innovating firms increases with size. On aggregated level in Europe around 20% of small innovators have collaborative arrangements, while approximately 50% of large ones in the manufacturing sectors, and around 35% in the service sectors do so (EU Commission 2001).

5.1.3 The scientific community

As indicated above it would have been reasonable to assert that the term 'scientific community' could embrace universities, public and private research institutions, research departments in organizations etc. the term is used here to describe the universities, of which Denmark has 12.

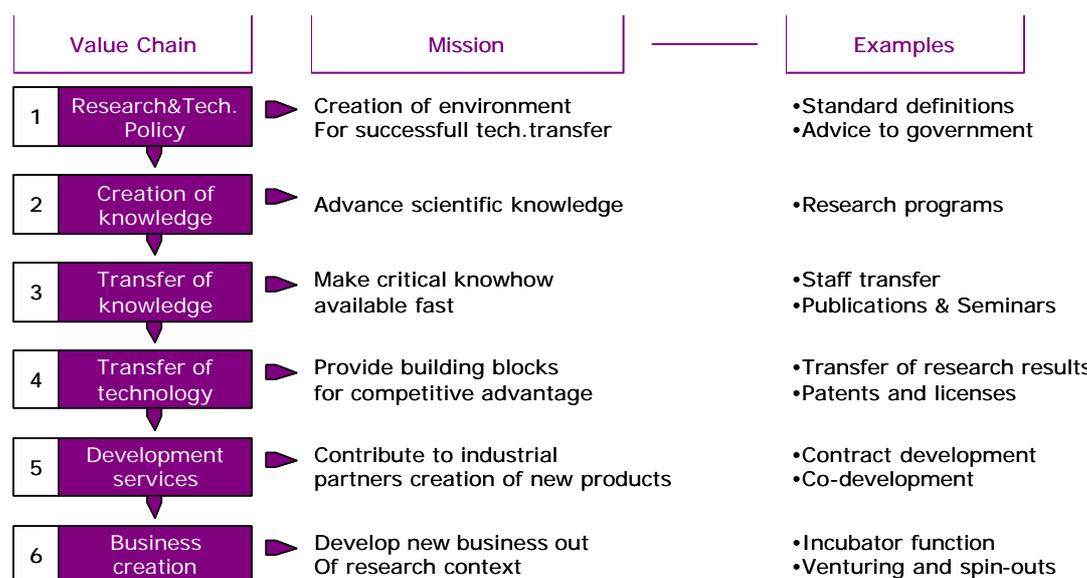
As mentioned during the historical introduction in chapter 1.2 the main tasks of the universities are the education and production of good candidates and furthermore to conduct high-quality basic research.

5.1.4 Formal structures

Apart from the universities in the role as primary knowledge producers other players have emerged in the institutional landscape by government initiative – as part of a national system of research counseling. These represent both the policy and the institutional infrastructure. Below I will characterize the different groups of institutions in this subsystem.

I will use the term formal structures to describe this system of public and semi-public institutions working as both knowledge producers and knowledge transmitters in society. These public and semi-public research institutes vary widely in respect of the resources and effort they devote to technology transfer. Depending on their specific circumstances, and the balance struck in their missions between the needs of government authorities, national industries and other stakeholders, their activities may be primarily in the area of basic or strategic research, or alternatively may focus on contract research and the development of applications.

The value chain of these institutions is pictured below and it is clear that it does not represent a linear process as described by Vannevar Bush, but it highlights the different components of knowledge transfer in the institutions. Although the emphasis that each institution places on individual components will differ, most will be active to some degree at all points along the chain.


 Figure 5.1: Knowledge transfer value chain of mediating institutions²⁵

As can be seen the main objectives of this system are²⁶:

- Counselling on all levels in Danish companies
- Independent of interest
- Secure and promote a responsible resource utilization in the interest of society
- Balance between research tradition and new thinking
- Coordinate counselling activities
- Represent both users and suppliers
- Contribute to an efficient utilization of research results for the benefit of society and business

Government Research Institutions

Sector research covers a long range of different public research institutions, placed under different Danish ministries. The aim is to provide the ministry in question with research based counselling, and sector research constitutes about 20 percent of public research conducted in Denmark. The research focus is primarily problem oriented, with a clear purpose of application in society.

Committees and Research councils

²⁵ Source: adapted from "Building an Innovative Economy in Europe" published by the European Commission's Directorate-General for Enterprise 2001

²⁶ Source: Danish Ministry of Research and Information Technology, www.fsk.dk - now the Danish Ministry of Science, Technology and Development (VTU)

The primary tasks of research councils are to support fundamental research within different areas and to give advice on the role of research in the development of Danish society with a view to a better coordination and prioritizing of the overall resources available for research.

Technological Service Institutes (GTS)

The GTS-institutes are functioning as self-governing institutions of public utility. No more than 13 different institutes are spread around the country, with each their own strategic and business focus. The GTS' are privately managed and management has the sole responsibility that the institute survives and develops in relation to its competences. The institutes sell counselling services on commercial terms to a broad range of Danish and foreign firms mostly SMEs. Revenue from these processes is used for consolidation, development of services and research and development.

The main focus of the GTS-institutions is to develop and transfer knowledge to different companies, and let this knowledge be internalized in these companies.

Science parks / innovative environments

The primary goal of the science parks is to promote and enhance the establishment of new companies through the use of knowledge from a range of research institutions connected to the science park. Science parks are settled in specific, limited geographic areas and are mostly connected to one or more universities. Thus, science parks are in some ways part of the university infrastructure.

5.1.5 Informal structures

The scope of the informal structures between the actors in the model is quite difficult to map. According to the informal character of these

structures it is very difficult to investigate them and measure to what extent informal structures are more common than formal ones. Yet it seems very reasonable to assume that informal networks and structures play an important role for most organizations and individuals. Informal structures exist as a web structure between all the actors in the model, between similar actors and across institutional and political spheres as well. The most indicative examples of informal networks are the networks of individuals – constituted by former fellow students, former colleagues etc. Moreover many organizations have placed themselves in networks of informal character. A good example is informal partner networks, where organizations in the same branch team up and give presentations on what they do at the moment. Conferences of this kind first and foremost exist because they bring people together and because there's a need for continuous cultivation of ones network.

5.1.6 National Innovation Culture

The efficiency of innovation systems is a key determinant of national and regional competitiveness in the global, knowledge-driven economy. In that sense the state of the innovation culture is very important. Functioning as the foundation on which the actors in the model act and take decisions it is of extreme importance that the culture of innovation is nurtured.

As noted earlier, innovation is systemic rather than linear. That is, the processes of innovation are multidimensional. They involve many different players, and often take place over extended periods of time and are rarely an isolated event. The speed and the success of the transfer almost certainly depend on other interactions, before and after the transfer itself, and are heavily influenced by conditions in the local and national innovation environment. Innovation therefore requires the development, over time, of highly interconnected systems. Well functioning innovation systems in particular serve to ensure the free flow of information across the interfaces between large firms,

researchers, entrepreneurs, investors of all kinds, consultants, patent agents, intermediaries, local authorities and other actors. In a Danish context, the nurturing of a national innovation culture has been prioritized through different systems of counselling, enhancing the possibilities of potential entrepreneurs and urging these to further investigate the potential of their ideas²⁷.

In close connection to the functioning of the national innovation culture and the system nurturing this culture, of course are capital structures. An important part of the innovation process, whether discussing business start-ups or innovation in existing companies the access to capital of different kind is essential. Thus, the functioning of capital markets, more specifically the access to funding and venture capital is extremely imperative for a well-functioning innovation system.

²⁷ The Danish "Iværksætter-model"

6. Case study – knowledge production and research collaboration in Denmark.

As mentioned during chapter 2, the empirical foundation of the thesis is a multi-case approach of 10 interviews with research managers and floor-researchers from 5 different knowledge producing institutions:

- Universities
- Science parks
- Government research institutions (sector research)
- Large science based industry
- Science based SME

6.1 Scenario approach

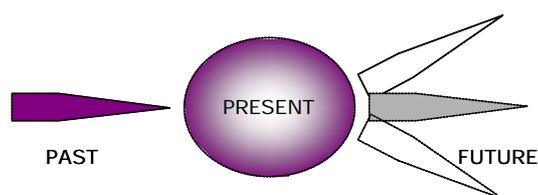
As indicated by chapters 4 and 5 the constitution of actors and factors influencing the production of knowledge reveals a very complex set.

New opportunities and initiatives appear so rapidly that traditional strategic planning may be too constrained to properly respond to these changes. In reaction to this 'weakness' of strategic planning I will take a scenario approach in the following and try to challenge the prevailing mind-set of this area²⁸.

It will be reasonable to describe scenarios as stories about the future – about thinking the unthinkable. A scenario plan creates several stories. Each identifies how various elements might interact under certain conditions that I will characterize 'ceteris paribus' conditions²⁹.

²⁸ 'Scenario planning is a discipline for rediscovering the original entrepreneurial power of creative foresight in contexts of accelerated change, greater complexity, and genuine uncertainty.' Pierre Wack, Royal Dutch/Shell, 1984

²⁹ Ceteris paribus – latin expression for "other things being equal". The notion is especially used in economic literature.

Figure 6.1 : Scenario perspectives³⁰

The scenario approach does not create a single future contingency plan, yet it attempts to capture the richness and range of possibilities in a complex environment where different actors take different decisions (Shoemaker 1995, Bloom 1994). Using information about driving forces (e.g. from society, technology, economics, politics etc.) that exist in the model of the knowledge producing sector, a series of scenarios can be created to provide an image of what conditions would be necessary to allow for the development of the most efficient environment where actors in the model can interact and mutually gain from it. Constructing the scenarios will hopefully shed light on extreme cases and help to clarify the values that will preserve and nurture the collaborative environment. It is not the aim of this scenario approach to evaluate and test the implications or potential outcomes of the scenarios, nor to fully estimate the probability of each scenario (Shoemaker 1995). Yet the identification of emergent tendencies and risks for the different actors and factors will be prioritized. The author has strived to keep an open mind, and tried to avoid the temptation of becoming attached to a particular scenario and tried to put predetermined notions aside.

The steps to build the scenarios have been:

³⁰ Source: own production

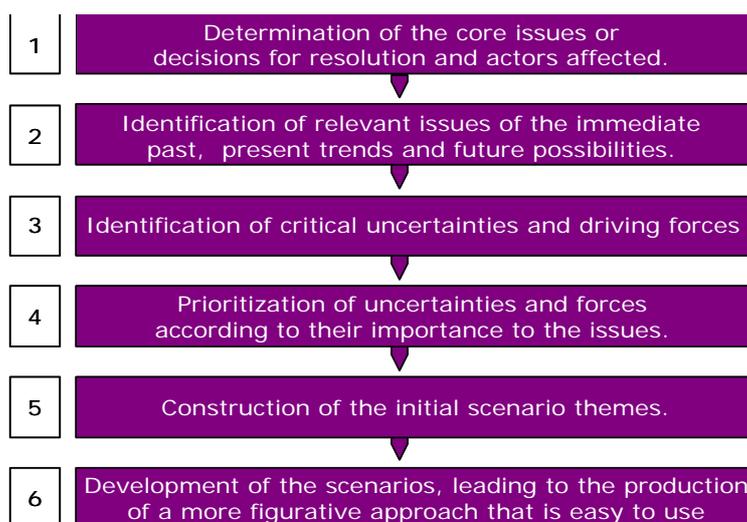


Figure 6.2: 6-step scenario plan³¹

The scenarios are founded both on the literature used in this thesis as on the interviews conducted.

6.1.1 Basic assumptions of the approach

As noted earlier the *ceteris paribus* condition connected to this scenario study, is chosen to comply with the time and resources at hand, and furthermore to focus on the most imperative issues and actors. Due to a very large number of emergent forces it would have been simple to create a bundle of more or less likely scenarios. In that respect the analysis has been committed to four scenarios that seem to be the most relevant to the sector as a whole.

In addition, keeping a range of forces at a constant level during the scenario analysis has been a necessity. A range of these variables are presented briefly below:

- National innovation culture
- Policy initiatives and restraints.
- Informal structures
- Social issues
- Capital infrastructure

³¹ Source: own production. Inspiration from Shoemaker 1995, Bloom 1994

The variables are not to be seen as totally irrelevant for the scenario picture as they contribute and inflict on the main basis of the knowledge producing sector - and holding them at a constant level does not automatically rule them out as influential indicators. Consequently the variables will be used as steady state indicators of possible development paths in the sector. For instance, statements from central political hand will be used as indicators of possible development paths in that sub system, yet will not be treated thoroughly.

6.1.2 Scenario #1

'Boundary organisations in full bloom – the medieval university'

Key characteristics:

The most important task of the universities is to educate competent graduates and to conduct basic research. It's not the aim to internalize the handling of commercial aspects in relation to knowledge production – it's about maintaining the endless frontier.

In this scenario mediators become very important actors – constructing an infrastructure, on which Danish industry can utilize research from public research institutions.

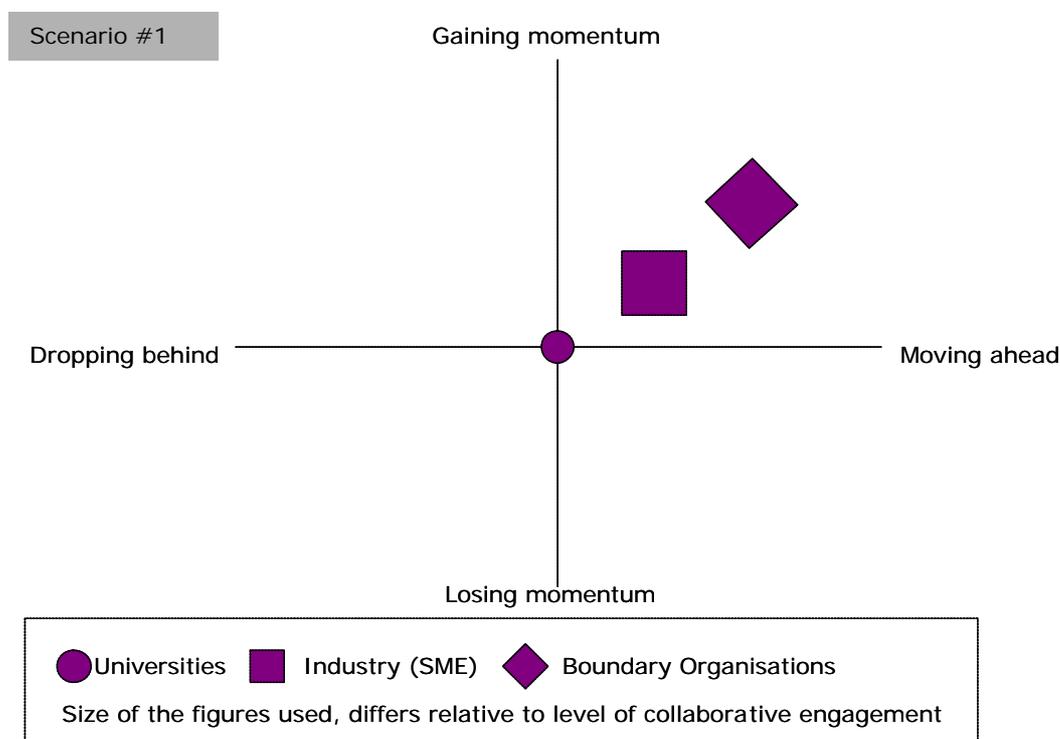
Elaboration on scenario: (See figure 6.3 below)

Scenario #1 fundamentally constitutes what can be classified as the notion of the endless frontier³². Universities ultimately remain in the state of the 1st academic revolution with a clear focus on education and basic research. Basic research is considered to secure innovation in the future – and the appliance of basic public research thus is lagged a decade or two before use.

Since the universities remain focused on internal tasks, there is an emergent need for smoothly functioning knowledge channels that can transfer knowledge from universities to industry. This infrastructure is

³² As described in chapter 1.2

built on the foundation of boundary organisations/mediators that act as knowledge transmitters between the two parts. Boundary organizations become very important in that setup, fulfilling their most important task as knowledge transmitters.



Figur 6.3: First scenario plot³³

6.1.3 Scenario #2

'The collaborative university – Boundary organisation in steady state'

Key characteristics:

Universities internalize the handling of commercial perspectives, IPR, negotiations of contracts etc. in relation to their knowledge production and become their own agents. They become equal partners to the industry and engage in direct collaboration without the use of mediators/brokers. As funding is a key issue only large industries will be able to satisfy the monetary needs of the universities and at the same time overcome the cultural barriers between researchers and non-researchers, cultural differences, short and long run perspectives etc.

Small and medium-sized companies will be kept out of the game and mediators will have to secure SMEs participation through knowledge transfer and counselling services to these.

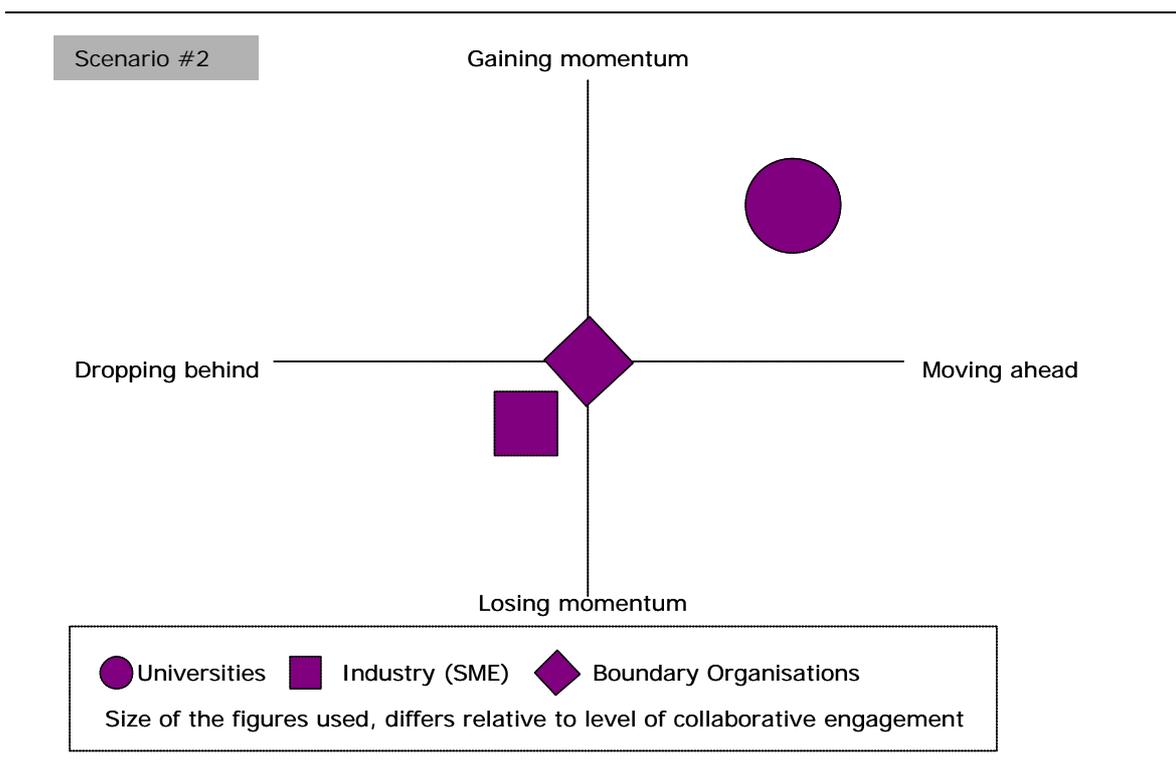
³³ Source: own production

Elaboration on scenario: (See figure 6.4 below)

In accordance with the 2nd academic revolution universities increasingly will focus on the production of socially accountable and applicable knowledge³⁴. On a managerial level the increase in interaction with external partners brings the universities on a learning curve on how to create the best possible outcome of collaborative arrangements with the outside world. Due to funding and cultural issues, the negotiations of agreements with SMEs have proven to be far too time-consuming and difficult. Contracts of DKK50.000 takes up even more time than a DKK500.000 contract, because of risk aversion, time horizon, financial incompatibility and lack of collaborative capabilities in the SMEs. In that respect only large research oriented companies will enter into agreements with universities.

In this environment mediators play an important part as counterpart of the SMEs. With their lack of cultural capabilities to make use of public research and of network resources that brings them in contact with usable research, SMEs increasingly need intermediaries acting as knowledge agents for them – both as transmitters as well as translators.

³⁴ See chapter 1.2 for explanation

Figure 6.4: Second scenario plot³⁵

6.1.4 Scenario #3

'Boundary organizations in crossfire - Survival of the fittest'

Key characteristics:

Large industries and universities will overcome all potential barriers in collaborative arrangements. As a consequence both monetary issues as well as issues on knowledge sharing and reflexive learning are coped with from both sides. SMEs are not capable of getting into collaborative arrangements, because of a lack of competences and of the ability to invest properly. Eventually it's a question of Darwinism – survival of the fittest. At the same time governmental research institutions servicing SMEs will have to rethink their position in the knowledge producing sector. As there's not enough money to earn from servicing SMEs, it will be a necessity that the mediators focus on new markets in order to stay alive.

Elaboration on scenario:

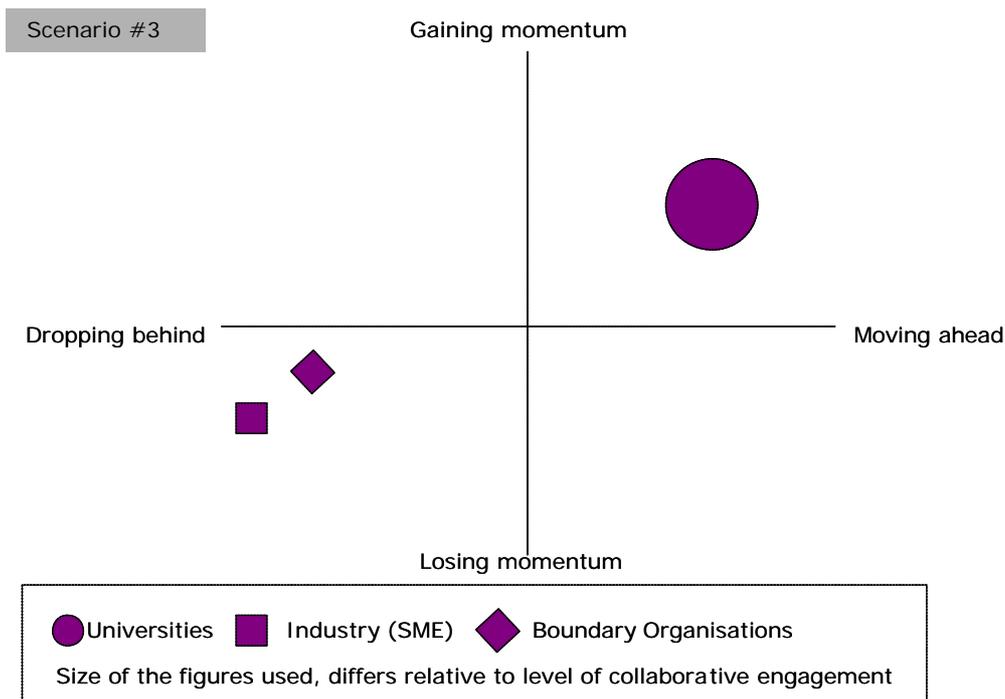
By overcoming all thinkable barriers in collaborative agreements, universities realize the full potential of their research. By internalizing all the necessary capabilities in relation to negotiating collaborative

³⁵ Source: own production

agreements university research is utilized to the full extent creating win/win situation for both universities and large industrial companies. The permanent existence of monetary and cultural barriers as well as a lack of risk-willingness in the SMEs has radical influence on their overall performance and contact to external partners – both universities and mediators. Most importantly SMEs cannot keep in step with their intermediaries. The market for counselling SMEs is declining due to a disproportional relation between the time used for contracting and the turnover from a task. Thus, the search for new market possibilities is prioritized in the mediating institutions as to secure survival in the future market for counselling services.

For the pool of SMEs it will be essential to rethink and reconsider ones strategic position in respect to survival in the future. Linkages to former competitors as well as to companies with complementary competences will be a necessity to stay above the surface.

In the end it's survival of the fittest – the SME that has the ability to build up and place itself in a strong network formation or firm club might be able to overcome the problem by growing in size. The SMEs that are not capable of adjusting to this new setting will submerge.

Figure 6.5: Third scenario plot³⁶

6.1.5 Scenario #4

'The rise of corporate universities –change towards industrial giants'

Key characteristics:

In a world of rapid change life long learning has become the prophecy of the future. Seeking to relate training and development strategy with business strategy corporate universities are developed to coordinate and develop intellectual capital in pursuit of corporate aims and objectives. As a direct consequence the traditional universities face two possibilities of either losing part of their business to new autonomous corporations or building strategic partnerships.

From the point of view of SMEs the possibilities to influence educational and business structures are decreasing and their overall potential as partners might well not be realized. Again SMEs struggle for position in the knowledge producing sector – both in terms risk-willingness, capital, collaborative capabilities and lack of possible linkages with neither universities nor public research institutions.

Elaboration on scenario:

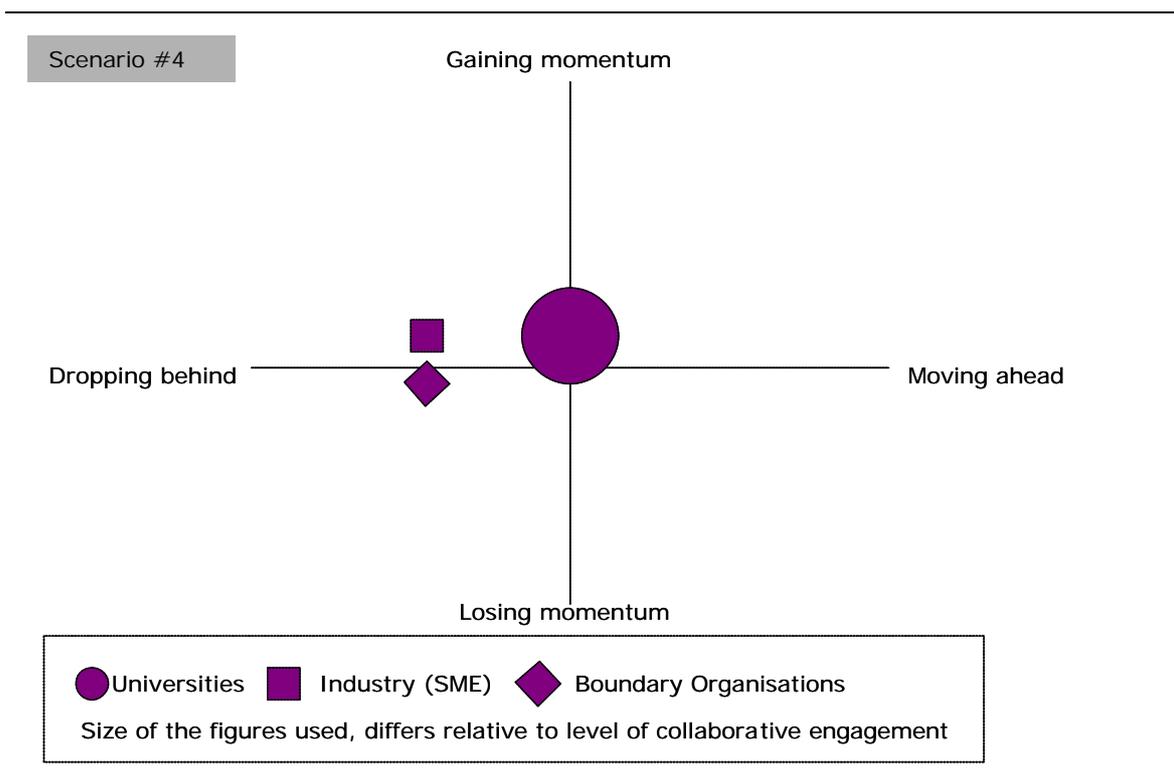
Placing organizational learning in line with business strategy is one of the recent trends in the learning strategy for large corporations' world

³⁶ Source: own production

wide. By developing either own programs or learning alliances with traditional universities corporations engage actively in advanced internal knowledge building in the corporation and in building valuable employees into future leaders.

The development of corporate learning is not intended to replace the rigor of traditional education. Quite obviously the competences of a traditional university are somewhat different from those of a corporate university – competences that a corporate university will not be able to internalize. For example, traditional universities foster a broad, integrated frame of reference that draws from a wide, multidisciplinary spectrum. But a fruitful collaboration between the industry and universities has to exist in order to create a win-win situation. If certain candidates are needed in the industry and universities don't provide the means to deliver these, corporations will surely try to bypass the universities and go directly to the source of what they want to be taught.

In relation to SMEs the outcome of this development again challenges the SMEs. The individual SME will not be able to inflict on market-driven tendencies in education. Neither will it be able to start own large scale programs to stay ahead of competition. Again the capabilities of the SMEs to create linkages and networks to competitors, public research institutions etc. will be a key resource to stay competitive and alive.

Figure 6.6: Fourth scenario plot³⁷

6.2 Scenario assessment

As noted above, the use of a scenario approach gives the possibility to construct a wide path of possible future development of the knowledge producing sector as also indicated in figure 6.1. In that respect it should be noted that the approach is characterized as a long-range planning tool based on past experience (Wright 2000, Shoemaker 1995). Therefore, further inspiration to the formation of these scenarios comes from both the theoretical grounding of this thesis and also from indications from the interview sessions conducted.

The aim of using a scenario approach in this thesis was trying to plan a plausible direction for the actors in the Danish knowledge producing in an easy-to-use framework. Henceforth, constructing a figurative approach to the different scenarios has been necessary for disseminating the results. This figurative approach builds on the plots used above, yet also tries to sketch the results in a new way - hopefully adding to the applicability of the scenarios. Due to complexity the

³⁷ Source: Own production

scenario assessment will embrace all scenarios at one time. Most indicative trends and forces in literature, recent statistics, interviews and public media influencing the chosen actor subsets will be the focus area and the objects of discussion during chapters 6.2.1 to 6.2.4. Chapter 6.3 will constitute a more general and more direct approach to pinpointing some imperative developments in the area of knowledge production.

6.2.1 Industry perspectives

From an industry perspective, the scenarios above have focused only on the conditions of small- and medium sized companies. This focus rests on the fact that SMEs are the most prevalent company size in both Denmark and in most European countries³⁸. At the same time a tendency towards downsizing of larger firms, due to outsourcing and focus on core competencies, adds to the high percentage of SMEs in the overall population of companies.

In a Danish policy context, the industrial composition is gaining much attention as SMEs play a major role as both important knowledge producers as well as generators of employment. The prevalence of SMEs and the diversity among SMEs raises certain complex issues in relation to innovation and entrepreneurship and the securing of steady economic growth. At the same time the scenarios above propose a problematic future for the average SME in Denmark in a collaborative context.

Specific SME characteristics inflict on their performance in collaborative arrangements with either industrial or university partners. As mentioned above the boundary organizations play an important role for the SMEs. Yet, market and political forces indicate a difficult future

³⁸ In Denmark in 1996, SMEs accounted for almost 100% of firms (the share of large firms in the total amounted to 0.2%); very small firms (0-9 employees) represented 92% of the total. *Source: OECD SME Outlook 2000 Edition*

for the cooperation between SMEs and the boundary organizations. As expressed by interviewees:

"The reason why large counselling firms don't work so much with SMEs is due to their lack of financial capabilities. To put it simple, there's not enough money involved. As we are competitors in the same market we have to look in the same direction. The worst-case scenario is that we lose the less active and less educated SMEs, in the race for collaboration."

"It's extremely problematic and I'm very worried. What will it mean for all the small companies? I really see a huge polarization that doesn't benefit the overall state of things. The few interesting firms and the broad pool of less interesting that don't get any attention in spite of their important role as job creators. If these companies are not helped – then I'm afraid they'll be lost. And that will have consequences."

"...Risk-willingness, IPR, willingness to engage in science which is long-term related. That has proven to be a huge problem for some companies that we've talked to. In US it's much for large industrial opponents to engage in the same projects as to secure competitiveness in the future. Denmark is plagued by the influence of 'Janteloven', and thinking small. In these times of globalization, out-reach and thinking big would be very positive. You face the question: 'Do you want a small part of a big pie or a large part of a small pie.'"

Nevertheless, SMEs are still attributed with certain strong characteristics and possibilities in contemporary literature. Characteristics that both enhance their performance and makes it possible to overcome some of the above mentioned barriers in innovation and entrepreneurship, exceeding the performance of large industrial counterparts. Some of the important features to be mentioned are:

- *Adaptation to market and trends and the ability to change-over production methods*

In an increasingly unstable and ever changing environment the need for quick restructuring and adaptation to markets and new trends is important.

- *Contributors to job creation*

SMEs account for approximately half of the employment generation in the OECD area, especially due to quick entry and exit rates (OECD 2001). This number, of course varies a lot from sector to sector and from country to country

- *High growth firms*

With respect to innovation a smaller subset of technology-based SMEs represent the top 5 to 10% of growing firms (OECD 2001, EU Commission 2001). Again, their role as job creators exceeds that of large industries. Moreover, there are indications that high growth firms usually are innovative or have been through a innovative process that has lead them into high growth. Such companies are mostly situated in areas of high economic and entrepreneurial activity, hereby engaging these SMEs in clustering, networks and other kinds of informal and formal relations.

- *Vertical and horizontal integration*

The increased interaction by innovative SMEs with other companies is a key instrument to overcoming potential barriers of being small (OECD 2001, 2000).

Small firms are more likely to outsource the production of inputs because they are unable to reach the necessary scale efficiencies in-house – especially due to: 1) the firms would incur often significant up-front costs for producing the inputs and 2) its level of production would not meet the demands of a large market outside the firm.

This is where interaction with other companies comes in. Such interactions involve both horizontal and vertical inter-firm collaboration between competitors in the same market and between suppliers and customers along supply chains.

This positive view of SMEs as partners both vertically and horizontally is furthermore underlined in relation to university collaboration:

" It's easier for a SME to engage than for the larger companies. They're more willing to co-fund e.g a Ph.D student. Big companies have become so big that communication and exchange of info has become so slow, and who will then take the ultimate decision whether to join or not."

" They don't see us as a threat to their research – that's very important. We're not big – we don't pose enough threat. People can identify with our size."

So to say – the ability to act fast with respect to important decisions and the length of chain of command proposes good possibilities. Though, a range of statements contradicting the positive view above arises.

" Large industries know exactly where the interesting research environments are located and there's already an extensive collaboration going on. The barriers for SMEs are that the two parts don't speak the same language – which they in my opinion should not. It is two different worlds. It's utopia to expect SMEs to collaborate on these conditions. There will be a collision of short term and long term goals. SMEs are not geared to participate in long term projects."

6.2.2 University perspectives

In many countries, universities have demonstrated, through their links to industry and their patronage of industrial incubators and industrial parks, the relevance of academic science and engineering research to the fostering of knowledge-based small and medium enterprises. Among the new technologies, information and communications technologies (ICTs) may play an important part in enabling developing countries to find new niches in the global economy, to receive information that will enable them to remain competitive.

In the same respect, there are many examples of fruitful collaboration between large industries and universities leading to inventions on which to capitalize. Yet with respect to the goals of the university, and the whole discussion on basic science versus applied science, mode 2 society and the triple helix (see chapters 1 and 3) a

whole set of questions arises in this collaborative environment. These are questions concerning both the university as an entity, but also performance and relevance questions in relation to both large industry and SMEs.

With respect to the question of the balance between basic and applied the focus on the primary tasks of the universities – to educate and conduct basic science is expressed by most interviews.

“ Research has to be interest-driven, and the scientist has to aim at becoming a specialist in his field. And if you are the best in a field automatically it will lead to applicable research. This can't be evaded. I don't believe in research management – the researchers' freedom is important – and attractive.”

“ (...)it's a balance, I'm worried about cutbacks in public funding to universities. It creates an increased demand for private funding, whereby scientists begin to plan their research to make it more attractive to industry. It's dangerous to aim for specific research in specialized areas. Basic science has to be the aim!”

*“ (...)They're here to educate people and to support basic science, and to provide an environment where people can look at different scientific problems.
....I think they'll maintain their role, and if they develop more on the commercial side they just become another type of collaborative partner possibility/competitor..... If the universities change the way they work it would just give us even more opportunities to work with them.”*

Still, the notion of unproblematic collaboration is not realized. There are still very important issues to solve when engaging in research collaboration from both the side of the universities and the industry.

“ Culture, securing the understanding of how fruitful research collaboration can be for both parts is important. It's obvious that one really has to give basic science the best possible conditions. We don't seek to change that – yet making basic science more applicable is important. For some universities and scientists it hasn't been 'comme il faut' to work with industry. We have to break down that point of view.”

“ From a industry point of view, the correlation between public and private institutions and the possibilities for collaboration are important. There are very few obstacles for the individual scientist to engage in collaboration, but it has proven difficult to capitalize from the results. Furthermore it's in our interest that universities understand the rules to play by when collaborating with industry – or to be able to formulate the most desirable rules for themselves. ”

“ The universities are focusing on getting more and more out of their research, finding some ways to generate something that is commercially

useful and hereby earning money for the institution. This makes the interaction a bit more difficult. On one side the researcher is very eager to work with us and on the other hand the researcher wants more out of it than just the right to publish – they want some more out of their research.”

“ Both university and industry is on a learning curve and it will take some time until we all have reached a certain insight where the win-win situation can happen. Industry is usually focused on getting something for no money as to secure a higher profit, and that isn't a win situation for the university. This balance has to be reached. ”

“ It's very difficult and its changing a lot. Commercial applications weren't considered a possibility when I started at the university. Nowadays universities are much more aware of potential commercial cases due to IPR though they're often quite naive about it. They are certainly much aware of it and we deal a lot more with TTOs than we did earlier when we went directly to the individual scientist. It's an evolving situation.”

6.2.3 Boundary organization perspectives

The Danish national system of innovation is primarily based on the existence of former publicly funded governmental research institution as described in chapter 5.1.4 that now exist on traditional market-like conditions. And these organizations make up the largest part of the mediating sphere.

Between the creator and user of knowledge these entities, with their specific organizational capabilities, form a variety of functions as distributors, integrators, intermediaries and brokers. The diversity of these institutions has been addressed earlier in this thesis and hasn't been the object of much attention in either the interviews or the scenarios. Focus has been to shed some light on their long existence as actors in the Danish system of innovation and business creation. Growing up as publicly funded institutions and now functioning on market terms like other privately owned companies has put mediating institutions in turbulent waters during the last decade. Firstly, their reputations as free and independent counselling services runs head on with the institutions struggle to secure a decent turnover in the market.

“Governmental research institutions are a leftover from earlier times and universities themselves have to internalize collaborative capabilities - that

is a recent perspective. I hear this as an undertone and hope it is wrong. I think that the system would fail.

The Danish system of innovation hasn't survived this long without purpose – it's because it's value creating. Internally we have a job to do – to visualize the role we play. Governmental research institutions are not casual institutions. It's a political task to consider how we can make use of them in the best way. Constructive dialogue..."

" We think a lot about awareness and who our most important customers are. Changing perspectives in the Financial Policy imposes changes for us – things that need to be down toned and prioritized differently. What we need to do is to develop much more on the commercial side in the future. We need to stand out and stand alone. This is a major upheaval for an institution that has lived solely on public funds for many years. It's a major change of course and we work a lot with it. It will inflict on the performance of many parts. We need new aiming points (...) It's cost/benefit now!"

" If companies just tried to measure the extent of help delivered with regards to research and development from this institute – and we were performance paid. That would surely be beneficial for us. Companies should be more willing to admit this and pay for the services rendered. We do much more than we are actually judged by."

Secondly, the mediating institutions are situated in a sphere that has evolved beyond their range. The internalization of collaborative capabilities by both industry and universities has in some ways superseded the need for mediating services.

"(...) No, we don't use them [mediators] actively. We do get invitations to them. I would not say that these play an important part for us."

"(...) Personally I don't find it as satisfying as being directly in contact with the other part. They perform a middle man thing which means that they extract some money in the process – it's ok, but in the direct link is better (...)

They don't actually serve a purpose after the connection is made. Once the dialogue is made they just sit on the side waiting for things to happen. Of course they can provide with services like this department does for Novo to SME etc."

" I would like to think that I have a sufficiently good network to the academic community. We get many contacts by groups like that (...) usually they offer solutions to more general problems. We always want to be approached with opportunities from different areas, but we act on very few of them."

Still, these institutions encompass a range of functions that are not yet completely overtaken and solved by either industry or universities.

Apart from the traditional role of advancing science in emerging technological areas there's also an important task in promoting and diffusing knowledge into new services and products. And to do that the mediating institutions will need to adopt new strategies. On the positive side the institutions contribute to the overall national innovation capacity by serving the purposes below:

- Knowledge transmission
- Development of new products, processes and services
- Serving as training ground for highly trained personnel
- Forging connections between research fields and institutions (especially due to a poly-technical approach)

On the negative side, the problems mentioned in relation to servicing SMEs above are still very present. The facilitation of bridge- and cluster-building among SMEs and universities is not completely enough. The financial issues are very prevalent, and the fact that not many SMEs are capable of entering research collaboration purely as a consequence of financial issues needs to be solved. If this has to be solved by subsidizing the mediators, the question of whether this imposes unfair competition on pure private research centers.

6.2.4 Other emergent trends

The three chapters above have focused on identifying trends and indications of the collaborative performance of industry, universities and boundary organisations in Denmark. To round of, the following will identify other emergent trends that inflict on the performance of one or more of the three subsets in the knowledge producing sector in Denmark.

The relevance of the policy system and the political climate as an important variable in the knowledge producing sector is pretty obvious – this is also stressed out in the contexts of mode 2 and triple helix. Political decisions inflict on all the mentioned subsets with different

strength. The scope and importance of policy decisions is reflected in the time devoted to monitoring these in all three subsets.

" (...)it's something that we have to influence as an organization. We can't sit back as individual scientist and expect to make great discoveries. We need to ensure that we make use of the whole intellectual pool that we have, no duplication of efforts."

" It's important that policy secures a good environment for the universities and hereby secure the production of competent candidates. And the element of innovation is important – it's important that innovation and entrepreneurship gains some attention."

The linkage between science and technology and industry is also of very complex character. Science and technology is still the domain of the universities, which are largely state supported. As SMEs constitute the bulk of the private sector, the diffusion of technology is of extreme important matter as to secure the large pool of SMEs a fruitful position in the future competition on a global market.

" (...)The angle in research policy that is of my interest is policy initiatives focused on diffusion. (...) Diffusion of knowledge and technology to the business environment is important – and that is an important task for the research policy."

In a political context schemes set out to support SMEs will not function in the absence of an entrepreneurial environment. Therefore, framework programs set out to foster entrepreneurship are extremely important for SMEs, especially when judging the level of entrepreneurial activity in Denmark³⁹. Failure to value entrepreneurship, employment mobility, starting and managing new businesses and risk-willingness are some of the impediments to the level of entrepreneurial activity (OECD 2000,2001).

Considering the existence of networks and the analysis of both formal and informal structures in the model put forward in chapter 4.1.2 figure 4.3 also raises some questions. Evidently the use of formal

³⁹ The entrepreneurial activity in Denmark (as measured by the business start-up rate per 100 persons) is in the low end of the field. The rate is 1.8 compared with 6.9 in USA. (Source: OECD Small- and Medium Enterprise Outlook 2000)

networks by the interviewees, especially mediating institutions, is very low. On the contrary, informal relations are valued as one the most important inputs to renewal and innovation.

" We have arrived at a state where the institution is pretty well-known and that in many cases make people find us ourselves."

"We use all sorts of networks. As universities don't have any formal channels in which they publish things relevant to industry it means you have to know the individual scientist. People know us and especially the Internet has become a mass supplier of informal contacts. We have strived to become well-known in the academic community and we experience the success of it now."

Patenting and IPR issues (intellectual property rights) are relevant factors for all three subsets. The handling of patents is very different in each of the subsets and also between different actors in a particular subset. A general European tendency is very low degree of patenting activity compared to USA. According to recent statistics the level of European product and process patents are 44% and 26% respectively, compared to 52% and 44% in the US (EU Commission 2001)⁴⁰. The protection of IPR is mostly done through considerations on secrecy and speed-to-market than by patenting. When not using patents as disclosure, the inventor loses the monopoly to exploit his results. At the same time the possibility to experience duplication of efforts is increased as nothing is published like it's required in patent cases.

And as indicated by the interviewees solving patent and IPR issues will be key determinants for the success of research collaboration in the future.

" More commercial exploitation of discoveries are made in the universities, but that sometimes goes to quite extreme lengths. Most scientists are not that open about their research and only talk about their published work and things that are already patented."

" It will expand. The time where universities could say, we will not commercialize science are over. More and more universities apply facilities to potential start-ups. I think we'll see much more start-ups and spin-offs.(...)"

⁴⁰ As indicated in chapter 5.1.2 the application of patents also show huge variations between large enterprises and SMEs.

There's lots of money at stake, also in politics – the trend will surely continue."

" We haven't been particularly active with respect to patents. This could be a future possibility as public research institute. (...) It's a good picture on how our own self-understanding evolves. I see changes towards a more aggressive institute who wants part in the knowledge produced in collaboration with others."

" It's a fact of life that there'll be more of it. And universities will try to secure their profit on IPR."

" Patents are very important for every industry that's involved in inventions. A patent is actually a government legitimized monopoly. The idea is to make people invest time and money in something useful Patents are essential – without them you won't get reward for your work."

6.3 The future of research collaboration - Ceteris paribus scenario formulation/conclusion

As seen from the above combination of theoretical sources, recent statistics and the interviews conducted a very complex set of outcomes was revealed. Outcomes that are under steady influence of many actors and that has to do with such diverse aspects as:

- Financial capabilities
- Strategic behaviour
- Industrial structure
- Economies of scale and of scope
- Market speed and focus
- Patenting and market approach
- Institutional differentiation
- Management and cultural barriers
- Knowledge transfer/diffusion
- Modes of organization
- Collaborative performance
- Innovation systems
- Risk-taking
- Etc.

Trying to group and present these perspectives and trends is an intricate task, and to be successful it will have to build on the ceteris paribus clause as mentioned earlier. In that sense there's a potential risk of losing specific characteristics as well as the general view. Still I see it as a very important task to push some of the aspects to the extreme and to venture into concluding on some of the most possible outcomes in the knowledge producing sphere.

In order to be able to come to a decision as to what the real life effects of certain characteristics will be in the Danish research system this will happen below. In the subsequent the routing headlines will be: 'industrial capabilities' and 'innovation, policy and public research' as to grasp and present a juxtaposition of the wide aspects in this area.

Industrial capabilities

As pinpointed above, a prominent role in the context of innovation is played by industry. Yet, it is a fact that large inter- and intra-organizational differentiation exists, and not all firms in the industry have the capabilities to perform well in a collaborative arrangement.

The transition towards new forms of knowledge production e.g. 'mode 2' affects not only academics. The increased focus on new organizational and knowledge forms has both cultural and managerial effects that have to be dealt with. Integrating different kinds of knowledge as well as different kinds of people must be mastered by the industry today. Focusing on trans-institutional setups and the mobility of the work force it has become much more prevalent to share researchers. In the same respect, the ability to master an increased knowledge flow becomes extremely important to secure a high level of absorptive capacity – the ability to acquire and share knowledge across disciplinary and institutional boundaries.

Considering size as variable in relation to the success in research collaboration and in the formation of the knowledge society many sources attribute SMEs with a high innovative performance. Some of the key asserts in relation to innovation, new technology and employment creation are:

- a transparent organisation
- flexibility and fast response capability to change over goals and production methods
- a greater tolerance for higher risk initiatives
- a collegial organisational context that values ideas and originality and where all may profit directly from a successful new innovation

-
- a capacity to gain substantial rewards from market share in small niche markets
 - an improved capacity for integrating and handling complex sets of information and technologies to create a useful outcome
- (OECD 2001, EU Commission 2001A)

Yet in spite of the characteristics, the same studies show evidence that not all SMEs live up to the prophecies above. But where lays the difference in these results?

There are obvious reasons to believe that some SMEs can be characterized by the observations above. But at the same time diversity within the group of SMEs needs to be considered. The above mentioned aggregated characteristics of SMEs don't apply for a large part of SMEs, especially low-tech firms in both service and manufacturing sectors. In my opinion, the potential risk of generalising results and experiences from high-tech biotech and medical SMEs to other sectors where they certainly not apply has happened. There are no indications or basis for attributing e.g. a low-tech carpenter firm with the same capabilities as a small high-tech company. Although they both can be high performers in relation to production and labour creation they reach that status on very different grounds.

Considering patent and IPR-issues when comparing SMEs and large industries reveal a picture very much like presented above. In spite of entrepreneurial activity among a smaller portion of SMEs, the propensity to patent is very low. As noted also in chapter 6.2.4 patents fall as company size increases (EU Com. 2001). This is hardly a problem for all SMEs, yet it raises the question whether patenting isn't considered to be important for SMEs or the propensity is kept down due to a lack a financial capabilities. In this respect it's important to keep in mind that patenting is a very important activity as means of knowledge diffusion as well as the protection of intellectual property is important for attracting venture capital. In that respect the willingness to take risks as venture capitalist to provide the basis for innovation is also

problematic for SMEs (OECD 2000, 2001). The concepts of moral hazard and adverse selection as explained in chapter 4.1.1 plays a certain role in the lack of willingness to invest in start-ups and small companies without a proven track record.

Approaching the SME area in a managerial perspective other focal points emerge. Although a portion of SMEs actively focus on innovation activities there are still obstacles to overcome with respect to commercially exploit their inventions. Managerial barriers are still ubiquitous for SMEs considering both collaborative and innovative perspectives. Especially in high-growth and spin-off companies the founding researcher needs to support the company with marketing, business and financial understanding in order to create the best possibilities in the competition.

All in all, the above mentioned characteristics for the Danish industrial sector with very few large and a large pool of small companies reveal a more precise shading of the picture. It underpins the development sketched out through the scenarios and furthermore the perspectives put forward by both theoretical sources and interviewees in chapter 6.2.1.

Innovation, policy and public research

Having presented some of the most conspicuous trends in the development of the industrial composition and its relevance for the level of research collaboration and innovation above – I still need to go into collecting the important trends in the rest of the contemporary innovation system presented in figure 4.3.

As indicated earlier in the thesis it seems reasonable to put the area of boundary organisations under the magnifying glass once more. Being specific entities of the Danish system of innovation these institutions play a certain role in connection with innovation, policy and public research. Moreover their future role as actors in the system of

innovation was questioned during the presentation and assessment of the scenarios in chapter 6.

Paying special attention to the development and constitution of the industrial composition and to the original role attributed to these mediating institutions it is very clear that boundary organizations have landed in a 'vacuum'. Being largely challenged by universities, industry and other counselling institutions in their former core market has brought these institutions into the light of policymakers.

Having focused on the emergent problems in relation to the collaborative capabilities of SMEs automatically raises a line of questions concerning boundary organisations. First of all the financial capabilities of the industry to large extent influences the market in which boundary organizations operate – making it harder and harder to bring home revenue from the market. Secondly, the diversity of areas in which these organizations operate collides with the outsourcing, small-scaling and core competence tendencies seen in industry today. It is fairly reasonable to suggest that providing society with widespread economic and inspirational value, renewal and break-through knowledge, academic acknowledgement and documentation seems to be too much of a task for one single institution.

These points indicate a need for change and restructuring in the self-understanding of boundary organizations. It's not a question whether the efficiency of innovation systems is a key determinant of national and regional competitiveness or not. Of course it is, yet the complexity increases when judging to which extent and under what form boundary organizations will contribute to the production and utilization of knowledge in the future. If boundary organizations are to constitute an important link in the Danish innovation system and not a bygone concept, in my opinion some of the following focus areas need to be considered – through internal and external evaluation:

-
- Need for solving the financial imbalance emerging in collaborative arrangements with industry (especially concerning SMEs)
 - Requirements to re-evaluate the needs for mediation and knowledge transfer in the industry
 - Evaluate whether funding incentives should be given to boundary organizations as SMEs are often unable to finance collaboration,
 - Need to reduce and simplify the regulatory and administrative environment that impedes on successful research collaboration.

Indications throughout the thesis have shown that the development of the university as we know it today – is object of huge changes both now and in the future. As knowledge-based industrial activities are increasing their share of the overall economies, and the resources devoted to knowledge production is also increasing, universities are situated as one of the central players in the economy.

As described during the introduction the university has gradually internalized new tasks along the way. The former focus on incompatibility between basic research and commercialization has, to some extent, been exchanged with a much more positive attitude towards incorporating industry perspectives when approaching different research areas. Many universities have therefore incorporated initiatives to work efficiently with industrial partners and the transfer of knowledge. Some of these include

- The interaction with the outside world has been prioritized to participate in the knowledge generation that takes place outside formal networks and research processes
- Human resource barriers like sharing researchers across projects and the mobility of staff has been improved as to eliminate the practical barriers that exist.

Still, especially evident in the interviews conducted, yet also expressed from universities themselves: education of competent

candidates and the conduct of basic research remain the most important tasks of the universities.

Unsolved managerial perspectives between basic research and the transfer of knowledge still prevail. Perspectives, that needs to be made explicit and worked with by industry, universities and policy system.

To round of, development might show that governmental forces will not be able to control the higher education system. Transformation of public research institutions into semi-privatized institutions is also signalling that industry and universities are moving closer and that education and research in the future will respond much more to forces of the marketplace than before.

7. Conclusion and policy recommendations

In order to investigate and gain insight in the conclusions, perspectives and outlooks presented in this thesis, the three elements will be covered in separate chapters below.

7.1 Conclusion

The production of knowledge – a prerequisite to maintain growth in all sorts of organisations, institutions and in regions and countries as a whole - this has been the overall research field of this thesis.

The notion of the knowledge society has been used to pinpoint the new economic trends and managerial challenges imposed on individuals, organizations, regions and countries as a whole – a whole new knowledge era.

The most indicative forces and factors in the knowledge society are connected to: 1. continuously **changing market structures**, 2. rapid **technological development**, 3. **use of ICT**, 4. increased **information flow** and complexity 5. **knowledge as the most important factor of production**. These factors impose new boundaries and form new possibilities for the production of knowledge.

The coupling of knowledge production and innovation has received massive attention from academia, industry and political hand during the last century, as the most important process in the pursuit to capitalize on new knowledge in the form of improved or new products and processes. Via complex systemic processes knowledge developed in both private and public contexts is utilized as key resource of production.

This thesis has worked with the concept of research collaboration from the three angles: academia, university and industry. As stated in the problem clarification the focus area has been to identify and explain the different barriers and factors that influence the level of research

collaboration between knowledge producing institutions – and in that respect to focus on specific relations and systems characteristic for Denmark. The study has been organized as an exploratory approach to the problem field concentrating on: 1. a literature study and 2. a qualitative study of five different knowledge producing institutions amounting to 10 interviews. These two main parts of the thesis form the foundation on which to base the conclusions.

In relation to the literature study, a thorough exploration of the theoretical contributions in a much dispersed field of related subjects has been conducted. The overall focus in that respect has been a macro perspective describing the development of knowledge production, science policy and the actors involved in the production of knowledge. Moreover the development of an actor/environment model describing both actors and the environment for research collaboration in relation to innovation in Denmark has been important.

In relation to the qualitative analysis, data from the interviews have been systematized to form more complete pictures of the different actors in the knowledge producing sector. These pictures have been used as objects of comparison to the pictures developed by theory whereby interesting problem fields have emerged.

As referred to above, the thesis initially focused on a historical presentation of the most important tendencies in the area of science and knowledge production – from the emergence of the universities up to present-day time. The presentation highlighted the most important shifts in the foundation of the knowledge system, especially transitions in the position of the universities and moreover the self-understanding of their own role as contributors to welfare and economic growth in society. Moreover the section provided the reader with the fundamental understanding and theoretical boundaries of the concept of knowledge.

The transition in the role of universities, consequently affecting the concept of science was the main theme in the literature study. From a broad range of scientific fields working with knowledge production and its relation to the development of society, various approaches explaining the transitory elements have emerged. Taken as a whole the approaches all advocate for an important role of knowledge with regards to the development of new processes and products through innovative processes. The production of knowledge has moved out of the universities and is conducted in many diverse constellations with the aim of achieving applicability in society and cross-disciplinary and cross-institutional collaboration- the so-called transition from mode 1 to mode 2 knowledge production. The diversification of knowledge producers means a rise in complexity in the innovation system, whereby governance and political intervention has become more important. Henceforth, incitements for relations between academia, industry and governance – the theory of the triple helix - are supported from political hand as to facilitate a high degree of collaborative and innovative efforts.

Increasing policy-intervention or governance in the area of knowledge production called for a thorough analysis of science and technology policy framework. The principal-agent model was used to exemplify the aggregated relationship between policymaker and scientific community.

Yet, by reworking and enhancing the basic principal-agent theory, it was managed to grasp special Danish characteristics, namely the function of semi-public intermediary institutions emerging in the area between policy and academe. These institutions, denoted boundary organizations, make up an important part of the Danish innovation system. Placing even more focus on the area between policy and academe brought about more complexity due to the diversity among the boundary organizations. Developing the concepts of both policy and

institutional infrastructures and furthermore dividing these into subsets of both formal and informal character helped to clarify the inter- and intra-organizational differentiation existing among all the identified actors in the model. Finally, revealing a pentagonal linkage structure.

Again, grasping the specific relations in Denmark, an identification of the actors or subsystems in the model developed was called for. By investigating the Danish research system in context of the model developed a picture of the important actors in the university-industry-society setup. This was necessary in order to be able understand the environment and both institutional and political forces at hand in the area of knowledge production.

With the foundation of the literature study and the development of an actor framework the case study was conducted. Focusing on relevant actors – identified archetypal knowledge producing institutions according to the actor model – the developed linkage structure was investigated; especially focusing on the three subsets: universities, industry (SMEs) and boundary organizations. The investigation was conducted with a scenario approach that made it possible to explore a very broad set of outcomes. Combining recent statistics, theoretical sources and the interviews conducted made it possible to both validate and in-validate assumptions presented in the scenarios. This thorough analysis brought forth some very imperative perspectives mostly affecting boundary organizations and SMEs, but also called the attention to the Danish science and technology policy, its function and scope.

From an industry perspective the overall level of research collaboration is to a wide extent impaired by the Danish industrial composition.

Having a large percentage of SMEs and very few large industries hampers research collaboration in many ways. Financial capabilities and risk-willingness are some of the most emergent barriers for small and medium-sized companies - both when it comes to collaboration with

other industry, governmental research institution and universities. These are some of the objectives that need to be solved by policy initiatives, framework programmes etc. aimed at restructuring the Danish system of innovation.

An important focus area of this thesis and also an important part of the innovation system are the boundary organizations. These organizations are automatically influenced by tendencies that have their origin in industry and academe, and as emphasized during the thesis, transitional trends and changes in the constitution and self-understanding of both industry and academe have situated boundary organizations with a recessive market. New demands to efficiency and cost-benefit-based considerations for these organizations will transform core tasks and markets in the future. It is questioned in this thesis whether the boundary organizations – as they are constituted today - have had their day in the Danish innovation system. Yet, to judge whether this could be a possible future scenario, it is important at the same time to assess who or which institutional arrangement that has to fill out the task of the boundary organizations. It has not been within the reach of this thesis to draw the final conclusion and explicitly give boundary organizations their mortal wound or the opposite. Yet it seems very evident that this problem field will receive attention from all angles in the Danish innovation system in the nearby future.

Last but not least, universities constitute the most important role as archetypical knowledge producers in the innovation system. Undergoing many changes since medieval times, universities have shown the ability to internalize new tasks along the way. This capability has been brought to play during the last two decades, especially in contemporary time, where universities are challenged from different angles in the innovation system.

Bringing the conclusions above together, draws a picture of a somewhat different innovation system compared to that we know today. It's clear from the conclusions and the subjects presented throughout this thesis, that research collaboration is not just about single actor subsets trying to collaborate in standalone projects. It's about complex intertwined durable relations that will have to be developed in the future. It's obvious that research collaboration is considered to be an advantageous activity by all actor subsets, but the potential of perceiving collaborative possibilities with positive connotations is not realized. Thus, identifying and developing the relations to become positive mutual dependencies between the actor subsets has not yet happened - in spite of the clear fact that all subsets exert considerable influence on each other already.

The prevalence of opaqueness, hostility and managerial and cultural barriers are still hampering the development of a well-functioning innovation system that incorporates the Danish characteristics. Solving issues with relation to intellectual property rights, patenting, risk-adversity and funding will have to attain highest priority by all actor subsets in future research collaboration.

7.2 Outlook/Perspectives

In order to be able to see perspectives of research collaboration in the future it's important to reflect on how this area of cross-institutional collaboration can possibly develop in the future.

As indicated from time to time during this thesis, research collaboration – the concept of university-industry relations – has received massive focus from the worlds of universities, industry and politics.

Referring to the description of the policy system given in 5.1.1 the continuous flow of political initiatives has widespread effects in the Danish innovation system. The very recent shift of government has of

course brought forth a range of issues concerning the conduct of science. Most importantly the shift meant cutbacks in funding to universities and the promotion of a more efficient system focusing on trans-institutional collaboration and applied science. Efficiency considerations have also shown the possibility of restructuring the Danish innovation system – especially concerning boundary organizations. In the coming years the bridge-builder role of these organizations, represented by Technological Service Institutes, Science Parks etc. will surely come under scrutiny on pure cost-benefit terms. Their relevance and value-creation has already been questioned in this thesis, and as well by government. The overall success in the knowledge economy is dependent on a well-functioning science and technology policy suited at catching developments in university-industry relations and the framework for innovation in a wider context. As European and Danish industrial structure differs from that of the United States there are still important policy-lessons to be learned when promoting innovation-driven economic development.

With respect to industry, adapting to overall framework policies is important and also to adapt their own practices to industry-science linkages. In that matter patent and IPR-issues have to be investigated and analyzed as they play a major role for the formation of collaborative arrangements.

Finally, the contributions from academia concerning research collaboration will have to draw forward good examples of the managerial and institutional framework that characterizes 'mode 2' knowledge production and formation of actors in the trans-disciplinary and –institutional setup depicted as the triple helix. At this very moment a large campaign called 'De spildte muligheder?'⁴¹ launched by the media house 'Berlingske Tidende' is focusing on the relationship between university research and industry. This is also a clear indication

⁴¹ In English: 'A waste of possibilities?'

of the importance collaborative perspectives raises and the massive attention that this area will attain from all the actors in the Danish knowledge producing sector during the coming years. At the same time it's an indication of an increased focus on presenting things more openly and to a larger group of people and interest – a focus on contextualization in the agora. In that context it is obvious that the self-understanding of the universities will be under increased inquiry.

7.3 Epilogue

As the last step in this thesis, time has come to position the scope and content of this thesis in a larger perspective, as to identify possible research areas in the future - research areas that can hopefully be developed upon the basis of this thesis. The bullets will not cover all possible directions but try to grasp the most important perspectives.

Specific Danish characteristics

The prevailing theories on research collaboration and university-industry relations have mostly evolved through US-based studies. These provide, of course, valuable information and knowledge, yet are not to use as generic guidelines that can be operationalized in other country contexts. Thus, there's an emergent need for further studies paying special focus on specific Danish issues hopefully revealing comprehensive up-to-date perspectives that can be used to rework the Danish knowledge producing sector.

Patenting and IPR issues

As patenting is considered to be of major importance in order to protect ones ideas and when realizing the commercial values of ones inventions, an investigation of patenting issues in relation to research collaboration has to be conducted. Patenting activity is lagging in Europe in comparison to USA and the reasons to this difference needs

to be investigated, not only on cultural grounds, but also in relation to regulatory barriers, strategic behavior and knowledge diffusion.

In relation to industry diversity there are reasons to believe that patenting is dependent on industry size – the larger the more active in patenting. Research into this relationship is particularly needed to address the problems of the large pool of both Danish and Scandinavian SMEs, yet patenting by universities and other institutions has to be considered as well.

Boundary organizations efficiency/value chain

As specific entities in the Danish innovation system boundary organizations have been under increased scrutiny. Investigation of these organizations has to be conducted, as to analyze their position in the Danish innovation system. Indications on possible development for these institutions has been touched upon in this thesis, still research angles that evaluate scale, scope and efficiency in relation to value-creation in the Danish innovation system is in demand.

Firm dynamics – intra and inter-firm diversity

Difference in industrial size is not just a question of scale in money and employees. More important is it to consider organizational, managerial and cultural capabilities – these are areas where the largest differences emerge. In literature SMEs are attributed with innovative and entrepreneurial characteristics yet it is evident that these characteristics are a clear simplification of state of things. Concluding from individual cases in specific sectors onto the aggregated level will not apply. Investigation of both industry size and industry sector in relation to collaborative capabilities is therefore needed.

SME-framework programs

As indicated many times during the thesis the composition of industry in Denmark has huge influence on the level of innovation. In order to be able to construct comprehensive, efficient and valuable programs for SMEs research in this area needs to be conducted.

These examples are just a few of the research topics that need to be addressed in the future and surely many more are to be elaborated on in future research on research collaboration and university-industry relations.

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