

THESIS FOR THE DEGREE OF MASTER OF SCIENCE

Dynamics of knowledge production in the Swedish Institute for Surface Chemistry, 1975-2005

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ABSTRACT

The Swedish industrial research institutes are research organisations that exist somewhat in between academy and industry, fulfilling an intermediary role as well as providing a space for research relevant to industrial companies, and they have a history of being collectively funded by state and industry as a way to support technical research in Sweden. The present study examines the history one of these institutes – the Institute for Surface Chemistry – with respect to three aspects of its knowledge production: the role that basic and applied research has played for the institute, its external connections and the heterogeneity of its knowledge production, and how it has evaluated the quality of its research. The time period considered is 1975-2005, a challenging time for the Swedish institute sector, and the analysis is based on an interpretation of annual reports, research programs and newsletters from the period, as well as on interviews with institute managers and researchers. This work contributes to a wider research field in two respects. First, it provides input to the ongoing debate about how a changing research system is linked to changes in knowledge production. Second, it increases our knowledge of the Swedish industrial research institute sector, something interesting in its own right but that also can provide input to the ongoing policy reorientation vis-à-vis these institutes. The main novelty of the work is that no other study has engaged systematically and historically with changes in knowledge production within this type of institute, and it demonstrates how the institute's knowledge production has been affected by external pressure.

To briefly summarise the results, applied research gradually becomes more important than basic research at the institute, but basic research still keeps playing a rather large role for some time, even as this role is downplayed in the official publications. At the same time, the institute becomes more heterogeneous in its knowledge production, associates closer with its industrial partners, and loses some of its independent knowledge production in favour of a more classic intermediary role. During the study period, the institute mainly ascertains the quality of its work through the use of traditional academic standards, and it retains a strong publication culture throughout. Three main conclusions are drawn: that the institute generally has oriented itself more towards its industrial partners; that this is the result of adapting to a situation in which the traditional state funding and political support appear ever more insecure; and that in spite of this general dynamic of adaption, the institute, thanks to a unique knowledge base or strong and well-connected actors, has sometimes had more space to run its own agenda, with some profound and long-lasting effects.

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As I sit down to write these final words of the thesis, it is August 22, 2011 – in a peculiar but very fitting twist of fate six years to the day since I started my bachelor studies at Linköping University. It is fair to say that at that time I would not have guessed that I would write the final words of my final thesis in a room on Molenstraat in Enschede – a city I then did not even know existed. Much in the same way, a year ago I would not have guessed that the thesis would be about Swedish industrial research institutes – organisations I then did not know existed. Nevertheless, here I am and that is what the thesis is about. Obviously, it took a lot of help getting here, and on this page I would like to give thanks to some of the people without whose support this thesis would not exist.

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1 INTRODUCTION

The work presented here is a study of one particular kind of research institution: the Swedish industrial research institutes. These are research institutions that exist somewhat in between academy and industry, providing a space for research relevant to industrial companies. Industrial funding, as well as government funding pertaining both to work in certain target areas and to more broadly defined long-term developments support their work, and they have as their purpose to stimulate knowledge transfer, while serving both industry and public interests (Bienkowska et al., 2010). They are thus neither identifiable with industrial laboratories nor with university departments (but most share certain characteristics with both). Using the laboratory typology developed by Arjan van Rooij (2007; 2011), they are research associations: organisations that bring together different companies and perform research for them. The institutes can also be understood as one way in which the Swedish state has supported industrial and sector-based research in order to bring about societal benefits, though the level of support for this particular model has varied over time.

In relation to the more fixed positions of universities and industrial laboratories, the industrial research institutes arguably occupy a relatively flexible position in the innovation system. Their flexibility make issues of the nature of knowledge production crucial matters for the institutes: how they should produce knowledge and what kind of knowledge they should produce are matters to which they constantly have to orient and re-orient while negotiating their stance in relation to government policy and to the positions of academy and industry. These dynamics – that is, the patterns of change and development – of knowledge production within the institute sector during the last three decades is the general area dealt with by this thesis.

The specific research topic is a case study that examines one of the institutes: the Institute for Surface Chemistry, with the aim *to explore and understand processes of knowledge production, and changes in these processes, in the Institute during the time period from 1975 to 2005*. This will be achieved by examining the institute's archive material and interviewing employees. The study focuses on three dimensions of knowledge production:

- The categories of basic and applied research: their role at the institute and changes in this role over time
- The external connections of the institute, its role in a larger research system and changes with respect to this over time
- The quality control measures of research used by the institute and trends in this use

An elaboration of the research topic and how it is motivated will follow in section 1.2 below. The research questions relating to the three dimensions of knowledge production will be given their final formulation after the theoretical framework has been presented in chapter 3. The rest of this introductory chapter is devoted to a presentation of previous research relating to this topic, to some remarks on the limitations of the work and on the terminology used, and to an outline of the rest of the thesis.

1.1 Previous research about the Swedish industrial research institutes

The Swedish industrial research institute sector is not the most well-researched of subjects. From a historical perspective, the industrial research institutes are taken up in a number of works that focus on Swedish research and economic policy more generally (see Petterson, 2011, for a review), and they are also usually mentioned in literature on innovation in Sweden (e.g. Gergils, 2006). However, this literature generally does not focus on the institutes as such, and given their small size and role in the larger research system, they are usually not given a lot of attention – they are only considered as (small) pieces in a much bigger puzzle.

A recent book chapter by Thomas Kaiserfeld (2010) engages somewhat more directly with the institutes. They are put into the larger context of intermediary organisations of knowledge transfer during the Cold War (essentially the industrial research institutes, the research councils and the so-called development pairs). The main thesis of the author is that the character of such organisations are best understood from a long-term historical perspective, and that a general historical trend is that dominating models of intermediary organizations are being imported into Sweden from abroad. In demonstrating this, the article rests on a rather valuable introduction to, and history of, the research institutes.

The institute sector in Sweden has undergone many governmental examinations and have been subject to a number of investigations on which to found reforms. Here the recent report of Sverker Sörlin (2006) on 'a new institute sector' deserves to be mentioned. This is a report prepared on request from the government, to function as a basis for a desired reorganisation of the public ownership and control of the industrial research institutes. Based on a solid research effort, it contains a very useful multi-dimensional overview of the institute sector, including the history of its development.

Two texts describe and analyse individual institutes in more detail. Lennart Eriksson (2010) presents the history and work of the Swedish Wood Research Institute (STFI, now known as Innventia) in a book that however is more personal and anecdotal than academic, and Ann-Kristin Bergquist and Kristina Söderholm (2010) have studied that Swedish Environmental Research Institute (IVL), focusing on its history and its research from the 1960s to the 1980s.

Finally there is literature produced by the ongoing research project that the present thesis itself is a part of. This includes both work that has less of a long-term historical perspective, for example on the integration of new skills into the institutes (Bienkowska & Larsen, 2009) or on the institutes' technological niches and their utilisation of findings from collaborative R&D (Bienkowska et al., 2010), and the historically focused PhD project of Ingemar Petterson (2011), which deals with the creation and development of the industrial research institutes, and governmental policy towards them, from the 1940s to the 1970s.

1.2 Statement of research problem, research motivation and research topic

Investigations into how knowledge is produced have always been important to science and technology studies, and in the last two decades perhaps more than ever. Judging by the number of recent theories relating to knowledge production and changes of the same, and by the continuing impact of at least some of these theories (see Hessels & van Lente, 2008; 2010), it does not seem far-fetched to conclude that the way research is performed and evaluated in contemporary society is changing, be it more or less radically. Judging by available empirical data however, matters seem to be less clear. What nevertheless is clear is that knowledge about such changes is highly relevant for scholars wanting to understand not only knowledge production, but also management of research and innovation.

Another thing that is clear is that the research institute sector in Sweden has undergone major changes of direction during the last four decades (Sörlin, 2006; Kaiserfeld, 2010). These changes, together with theories about how scientific knowledge production is changing, and the fact that norms of knowledge production always has been a highly important matter for the institutes, make the matter of if and how knowledge production in the institutes also has changed during this period very interesting. At present this is not well known, and this knowledge gap with regards to how institutes have produced knowledge is what this thesis aims to fill. That is, its general research problem is to investigate changes in knowledge production in the institute sector, in practice by making a case study of one institute and of the changes that have or have not happened within this institute.

It is possible to elaborate a bit more on the question of why knowledge production in the research institutes is an interesting topic for a study. To begin with, what is the relevance of studying the research institutes? To put it simply, the study of scientific institutions is an important part of science and technology studies in general. In the words of Bruno Latour (1999), such institutions keep the crowds of colleagues together, and thus they are part of what makes science possible. And studying the industrial research institutes of Sweden is interesting, partly because their size and role stands out in an international comparison, but also because their role seems to be changing today (see chapter 2), making knowledge about this role important. In the end, more knowledge about any kind of research organisation is relevant and interesting in itself, but in addition to this, one can hope that more knowledge about the research institutes will contribute to an increased ability to manage developments in the innovation system so that it develops in a desirable direction.

The matter of knowledge production, that is to say how it works when we create new knowledge, what norms and standards determine how knowledge is created and what will count as good knowledge is, as mentioned, another important issue within STS. Considering citation patterns of influential works in the area (see Hessels & van Lente, 2008; 2010), it appears to remain a much-discussed topic for scholars of research policy and of science. It thus seems an important matter to pay attention to. Finally, to study knowledge production in relation to the industrial research institutes is also important because their more flexible role in the innovation system might lead to new norms and standards quickly having a large and visible impact. Studying this can thus lead not only to a better foundation for innovation management, but also to an increased understanding of knowledge production and of users of knowledge in contemporary society.

Having thus briefly established the research problem and its motivation, it is necessary to clarify what the study actually will focus on, and why. The general idea is as mentioned to fill a knowledge gap relating to the dynamics of knowledge production within the industrial research institutes during the last three decades. However, obtaining a complete picture of the entire institute sector must remain beyond the scope of this thesis due to time and resource constraints. The earlier studies of the domain that do not focus on the sector as a whole or Swedish research or economic policy in a wider sense have normally studied individual cases, usually two different institutes (e.g. Bienkowska & Larsen, 2009; Bienkowska et al., 2010). A case study approach was also chosen for this thesis. Even if it hardly is possible to generalise too much between the various institutes (as they differ quite a lot from each other), a case study can be considered a suitable trade-off between insights and time spent. Even if generalisations are impossible, a study of a single case leads to knowledge about local conditions, something that is a valuable scientific result in itself (Flyvbjerg, 2006). A case study could also lead to insights that will be relevant for future research, and it will at least hint at whether or not the employed approach to knowledge production has practical (and not just theoretical) relevance for the domain.

The study focuses on a single case, rather than two different ones. On the one hand, studying two different cases would have been able to give the thesis a more solid foundation as well as room to argue and draw conclusions about identified similarities and differences. On the other hand, a study that includes two institutes instead of only one would by necessity either take twice the time or be less in-depth. The increased depth made possible by choosing only one case seems more important in this relatively unexplored context, so that approach was chosen. Furthermore, the focus on the workings of a single institute fills another knowledge gap, in that no previous study (with the possible exception of Bergquist & Söderholm, 2010) combines an in-depth study of the knowledge production of an institute with an attempt at tracing some of the historical dynamics of this production.

The studied institute here is the Institute for Surface Chemistry (generally known by its Swedish acronym YKI, for *Ytkemiska institutet*), an institute that is both research-intensive and of a reasonable size, and working in a field with connections to materials science, which has been suggested as a domain where changes in knowledge production should be highly notable (Gibbons et al., 1994). Two other options were initially considered (for practical reasons, only institutes in the Stockholm area were considered): the Swedish Environmental Research Institute (IVL) or the Swedish Institute for Computer Science (SICS). Both are, like YKI, scientifically oriented institutes and thus suitable considering the general topic of the thesis and its function as a PSTS graduation project. Both are also working in fields considered sensitive to recent changes in knowledge production (Weingart, 1997). In the end, IVL was dropped because it already is the subject of another ongoing historical study (Bergquist & Söderholm, 2010), and YKI was eventually chosen over SICS because it is slightly smaller (and thus more manageable), because it has an interesting tradition of being simultaneously very oriented both to the university with which it is co-located and to its industrial co-owners and because it has not been the subject of earlier academic study.

The time period studied in the thesis is from the mid-70's up until the end of 2005. The starting point is chosen as it approximates the start of the decline of clear government support for the research institutes that followed institutional reforms in the late 1960s and the 1970s. Another option would have been to start the study in 1968, the year of the highly important establishment of STU (the Swedish National Board for Technical Development; this organisation will be presented in more detail in chapter 2), but at that time YKI was still very much in the process of building up its organisation. There was also less material to analyse from these early years, and few possible informants. The study ends in 2005. It was the year when YKI became part of the SP-group (SP is another research institute, historically focused on testing and standardisation and controlled by the state; today several industrial research institutes are daughter companies in the SP-group), and so seems like a logical end point.

To finally bring the above discussion together, it should be made explicit why it is interesting to study the history of YKI and of its knowledge production. Firstly, by providing a historical account of a scientific organisation that is of a rather unusual kind – unusual both in the sense that the institute form itself is uncommon in Sweden compared to university departments or industrial research laboratories, and that the size and scale of the Swedish institute sector stands out internationally – it is hoped that the study can provide input to ongoing debates about changes in knowledge production within the fields of STS and research policy. In particular, the study will be able to throw light on how the knowledge production of this organisation has or has not been affected by actual and perceived policy changes, and by a mostly hesitant or negative policy orientation. Although this knowledge will be limited to the particular case – which in itself is seen as a valuable result – it is hoped that the study will also lead to insights relevant for future research in the area. Secondly, the study ties in to a larger project being performed at the Royal Institute of Technology, itself related to an ongoing reorientation of policy vis-à-vis the industrial research institutes. In this context, it is hoped that the study can provide a deeper insight into the history of knowledge production in one particular institute, thus filling something of a gap between work focusing on the history of the entire sector and work considering individual institutes in more detail but with less of a historical focus. This should be able to contribute to the overall goal of the project, which is to increase our understanding of the complex roles and niches that the institutes have and have had. Such an understanding is valuable in itself, but ultimately it might also contribute to better policy making.

To end this section, the main objective of the study can then be restated: It is *to explore and understand processes of knowledge production, and changes in these processes, in the Institute for Surface Chemistry during the time period from 1975 to 2005.*

1.3 Limitations

With this aim in mind, it is important to clarify some limitations of the thesis. Since the study focuses on the three dimensions of knowledge production outlined in the first section (basic/applied, external contacts, quality control), it follows that it is not concerned with knowledge production in a strict epistemological sense. It will for example not ask questions about the research methods of YKI or the validity or status of the knowledge that is produced there. The thesis also will not be an ethnography investigating the minute details of scientific practice at YKI. Though work in such a Latour-Woolgar tradition can be very revealing, it is not readily compatible with a historical approach. Instead of considering how research has actually been performed in the laboratory, the focus here might more aptly be described as being on the organisation of part of the scientific community (i.e. YKI), and on how research has been organised and evaluated within this part. Furthermore, it can be emphasised that it is a historical study, and as such it will not try to explain the case in terms of e.g. general sociological theory. It will rather attempt to follow particular (historical) internal and contextual dynamics. However, to a certain extent the historical approach will also be limited. The primary focus is on producing a description of developments internal to YKI. A complete account of the historical context will not be provided, mostly because of time constraints.

1.4 Terminology

It is also necessary to make a few terminological elucidations. The first one has to do with the term 'industrial research institute', which is a direct translation of the Swedish *industriforskningsinstitut*. This term, though widely used today, is a rather recent construction that lacks a formal definition. Institutes now known by this term have earlier been called 'collective research institutes' (*kollektivforskningsinstitut*), referring to their joint public-private nature, or 'branch research institutes' (*branschforskningsinstitut*), referring to their orientation towards different branches of industry. Today, the term 'industrial research institute', or sometimes simply 'research institute', tends to be applied to a host of institutes that have a tradition of collective funding and exist outside of the university system, whether or not they themselves use the term¹. However, the history of this terminology is not in focus in the thesis. Following usage inside the sector as well as most of the recent literature on the topic, 'industrial research institute' will be used throughout to refer to the group of organisations today normally known under this heading (see e.g. Sörlin, 2006). Sometimes this is shortened to 'research institute' or just 'institute' for the sake of textual flow, but unless otherwise indicated, the meaning stays the same. When the term 'institute sector' is used, it refers to the entire group of these institutes.

The second elucidation is of the term 'knowledge production'. In research policy work, this term appears to be employed far more often than it is precisely defined. It is also used within other areas of science and technology studies, and presumably takes on different meanings depending on the context. The term and its connotations are quite interesting in themselves, with the word 'production' evoking industrial and economic associations and creating an idea of knowledge as something produced – not to say manufactured – rather than discovered. But an exploration of the history and ideology of this term is, however fascinating it would be, a matter for a separate project. In the present text, 'knowledge production' as a research topic will be defined in a later

¹ Thus is IVL, the Swedish Environmental Research Institute, often considered an industrial research institute, though they themselves use the term 'environmental research institute'.

chapter. Until then it can conveniently be understood as a way in which new knowledge is obtained. Questions of how knowledge is produced thus relate to the manner in which research is organised, performed and evaluated.

Two other terms needing some attention are basic and applied research. They will be given more consideration in the chapter on the theoretical framework: here it just needs to be acknowledged that they have a number of synonyms and related terms and that they, like 'industrial research institute' or 'knowledge production', have a long and complex history, being the outcome of intense struggles and negotiations rather than being natural categories. The unproblematised usage of these terms throughout does not amount to an attempt to ignore or conceal this history, but follows conventional use and is for the sake of convenience. They will also be used as translations for two Swedish terms: *grundforskning* (sometimes *grundläggande forskning*) and *tillämpad forskning*, respectively. These are standard translations.

Some attention should also be given to the terms 'innovation system' and 'research system' used throughout this text. Such terms are used by authors who want to emphasise the complexity of innovation work in contemporary society, and/or argue for a policy based on a more systemic understanding of innovating institutions (Hessels & van Lente, 2008). Studies of innovation systems tend to stress the importance of relations between actors, artefacts and institutions. These relations create interdependencies between components of the system, essentially making it more than the sum of its parts (Carlsson et al., 2002). The use of such terminology here signals an approval of this understanding, even if the study does not include a system analysis as such. When used in the text, the terms refer to the research and development institutions of society and the relations between them, and acknowledge the structural and functional complexity of the institutional landscape.

Finally, a number of acronyms will be used throughout the thesis to refer to names of organisations and institutions. Generally the Swedish acronyms will be used: this seems to be standard practice also in English texts. Using the Swedish acronyms also avoids confusing a Swedish reader too much with unconventional signifiers for familiar organisations. The acronyms will always be introduced when they are first used; a complete list of acronyms and other special terminology is appendix B to this thesis.

1.5 Outline of the thesis

The thesis is divided into seven chapters. Following this introductory chapter, an overview of the institute sector is presented in chapter 2. This overview has primarily a historical focus, discussing how's and why's of the institute sector development, but it also includes some details about YKI and about the state of the sector today. The third chapter establishes the theoretical framework used by the thesis and employs this to formulate and motivate the research questions. Chapter 4 details the research strategy and the research methods. It discusses both the general approach taken and the specific methods and sources used. In chapter 5, the findings of the research are presented and analysed. Essentially the chapter is an extended account of the three dimensions of knowledge production at YKI, as understood from source material and interviews, as well as an analysis of this account. Chapter 6 discusses the findings in relation to the study's aims. It also discusses and criticises the methods used, to demonstrate to the reader what other paths could have been taken as well as the limitations of the approach actually used. Finally chapter 7 presents the conclusions of the study and four suggested lines of future research.

2 INDUSTRIAL RESEARCH INSTITUTES IN SWEDEN

The objective of this chapter is to give an overview of the history of the Swedish industrial research institutes, a snapshot of the current state of affairs, and a first brief presentation of the Institute for Surface Chemistry. This orients the reader to the general domain in which the study is situated, and it also serves as a foundation for the rest of the thesis in that it describes historical developments that will later be discussed in relation to the case.

To begin with, the history of the Swedish industrial research institutes is one part of the history of the Swedish research system, a part where public funding has been used to support industrial research and, by extension, industrial growth. One guiding question to understand this history can thus be formulated as follows: why and how has the state supported industrial or industrially oriented research? The main thesis of this chapter, relying mainly on earlier research by Sverker Sörlin (2006), Thomas Kaiserfeld (2010) and Ingemar Petterson (2011), is that the state supported such research because it was seen as important for societal progress, and that the collectively funded industrial research institutes were one way in which this support was administered. The support has been neither unconditional nor unwavering, however. After some early attempts at a collective model for research during the interwar period, the first proper industrial research institutes were set up during World War II, principally to improve conditions for long-term research within certain branches of industry. For various reasons, the growth of the institute sector however never took off and it remained rather small. Starting in 1968 however, a number of reforms and policy initiatives first served to increase state influence over the institutes and then to decrease their role in the research system, as policy makers who wanted to co-locate research and education more and more chose to support research at universities, which came to be seen as the ‘research institutes of society’. The institutes lingered on in a kind of political limbo, unsecure about the intentions of policy makers and finding it harder and harder to secure state funding. It is only in the new millennium that this situation has started to change, as policy makers are again seeing a clear role for the institutes as intermediaries in a new and more diverse research system.

Following that brief outline of the chapter, the history will be fleshed out in more detail. To go back to the beginning, the history of industrial research institutes in Sweden can be said to stretch back for the best part of a hundred years. Two early examples of research institutes co-funded by industry actors and the state were the Wood Pulp Research Association and the Swedish Institute for Metals Research, established in the late 1910s and early 1920s, respectively (Kaiserfeld, 2010). Although these two institutes did not have a lot in common with the institute sector as it came to develop after World War II, they arguably signal the starting point of the era of collectively funded and industrially oriented research institutes. And already the formation of the third institute came to have more long-lasting effects. Unlike the first two, whose origins can be traced to initiatives from affluent firms in important export sectors, the motivation for third institute – performing power and fuel research – was the difficulties of supplying the domestic industry with needed fuel and power. Public authorities and industry representatives collaborated extensively on finding a suitable model for such research, with the eventual end result being the establishment of the Royal Swedish Academy of Engineering Sciences (IVA), an organisation which came to house several smaller research institutes (Kaiserfeld, 2010).

Throughout the interwar period, this organisation received funding from public and private sources to perform research and form institutes, first in the fuel and power sectors and later also in other technical areas deemed in need of extra support, primarily the building sector. Nevertheless, the Academy was chronically underfunded, so the successful establishment of new

institutes relied on intensive networking and collaboration between the industrial sponsors and the academic researchers. This necessary close collaboration led, according to Kaiserfeld (2010), to a system where traditional academic norms for the evaluation of knowledge production (e.g. peer-review) came to exist side by side with industrial norms relating more to utility and profit.

The foundation for the more modern model for the industrial research institutes was established a little later, during World War II. One central factor in the initiation of this process was, according to Ingemar Pettersson (2011), an increased sensitivity to the importance of science and technology for social and industrial progress. This tied into an ongoing stream of thought about the exploitation of the social benefits of science, later associated with the British physicist John Desmond Bernal, but the importance of what was then known as techno-scientific research had been profoundly demonstrated also by the war itself and the practical problems it brought with it. This led to the government taking an increased interest in technical research as a societal resource.

Thus the government in the early 1940s appointed an investigating committee, the so-called Malm committee (after its chairman Gösta Malm), to study how increased public support of such research should be organised. Though the main industry actors preferred a model in which long-term basic research was carried out at universities while the industrial firms themselves were responsible for more applied research and development, the investigation found that there was a demand for public-private collective research as well, in particular in branches of industry consisting mainly of many small firms, where few or no actors had the financial resources to carry out research on their own. There were as mentioned precedents for such collective research – the interwar institutes had also been organised around a collective model – and the state was generally in favour of industrial cooperation (Pettersson, 2011). One of the government's main motives for the establishment of the new institutes thus came to be the desire to improve the conditions for long-term research within certain industrial branches. If the companies within the branches in question were willing to cooperate and collectively fund long-term research, the state would cover a certain portion of the economic risks associated with such research: their developmental risks would be socialised, to borrow a phrase from Mats Benner (1997). Often, the idea that the state part of the risk-taking should be used for basic or fundamental research while applied work should be financed by industry was also expressed, and basic research was at least in theory seen as central to the institutes during these early years (Pettersson, 2011).

When the four first 'modern' industrial research institutes were established in line with suggestions presented by the Malm committee between 1942 and 1945 (e.g. Statens offentliga utredningar, 1942), this motive and these ideas were the foundations. All four were established in close geographical proximity to one of the technological institutes of the country, and all had similar organisations. The economic framework for their operations was determined by agreements between the state and a foundation formed by the relevant companies, with the state covering most of the fixed costs, such as costs for the institute's premises and salaries for the employees (Sörlin, 2006). It can also be mentioned that the establishment of the institutes was not always without friction: the government generally took a more offensive position vis-à-vis the branches in which companies were not as willing to collectivise their research (for more details of these developments, see Pettersson, 2011).

Although the industrial research institutes came to function well in their role (Kaiserfeld, 2010), their growth never really took off, and compared to many other European countries the Swedish institute sector remained (and remains to this day) very small. One possible reason for this is the growth of a second model of knowledge transfer, the so-called development pairs (Fridlund, 1999). The early research institutes had mostly been formed within industrial sectors in which

there was no major government agency acting as a major customer. In the sectors where there was such a public customer, the innovation system developed differently and with much less political steering, with long-lasting relationships being formed between major firms and major government agencies (e.g. telecommunications firm LM Ericsson and the Royal Board of Telegraphy). These relationships were characterised by a large degree of trust, based around extensive interpersonal networks, and they were very beneficial for both parties, leaving no room for the growth of independent research institutes (Kaiserfeld, 2010; Sörlin, 2006). In the end, these development pairs came to dominate the Swedish innovation system, with the industrial research institutes functioning as a smaller complement catering mainly to smaller firms and industrial domains without a major public customer (a host of new institutes were set up in the 1950's and afterwards, but overall the institute sector remained very small). The system as a whole worked well and was able to meet quite high expectations (Sörlin, 2006) up until the mid-1970's, when a series of reforms were initiated, radically changing the entire Swedish research system.

Having thus reached the starting point of the study, it might be worthwhile to consider the developments from the late 1960's and onwards in somewhat more detail. The first major governmental consideration of the institute sector after its establishment in the 1940s happened in 1964, when the government appointed the so-called industrial research inquiry to evaluate the industrial research institutes and the system for technical research in the country more generally. The inquiry presented a first report in 1967, but at that point political changes had already rendered most of its suggestions somewhat obsolete. One of the suggestions nevertheless became real the following year: the establishment of a central organ for the administration of collective technical research, which came to have large consequences for the institutes. (Sörlin, 2006; Eriksson, 2010; Petterson, 2011)

Thus, in 1968 the Swedish National Board for Technical Development (swe. *Styrelsen för teknisk utveckling, STU*) was created, taking charge of government support of technical and industrial research. It was also given responsibility for the industrial research institutes and thus became the main public financier of institute research. The creation of STU was also an expression of an increased state involvement in the steering of technical research (while it is unclear how much this policy shift was shaped by external influences, it coincides with an international trend towards a science policy more focused on science as a means with which to reach other policy goals – also implying more state involvement in scientific research). If the guiding principle behind the financing of technical research up until that time had been that the state should be responsible for basic research, this was now largely discarded and the distinction between basic and applied downplayed. Naturally then, the idea that basic research was central to the industrial research institutes also disappeared in favour of a more applied focus (Petterson, 2011).

Most of the STU funding of the institutes was provided through three-year framework agreements with industrial foundations, which contributed half of the funds. Apart from this base funding, which often could be given with relatively few strings attached, the institutes remained free to seek industrial contracts as well as STU and industrial grants for particular projects. Partly as a consequence of the increased state involvement, public funding to the institutes increased quite a lot during the late 60s and 70s. For example, the public funding provided to YKI grew from 1,7 million kronor in 1970 to 3,9 million in 1980 (corrected to 2005 prices). (Sörlin, 2006, p. 28)

But if this was the heyday of the institute sector, new policies from the mid-1970s and onwards came to change things. As noted, the entire innovation system was reformed, with mostly negative consequences for the institutes. One of the factors that initiated the reform process was

a de-regulation of certain markets on which there had earlier been a public monopoly (Sörlin, 2006). This broke up many of the established development pairs. At the same time, public research grants were refocused to the at this time quickly expanding university sector², not in the least because of a political desire to associate the university education with research, and a growing belief that the need for academically trained researchers in the industry was not very big. It was seen as better if researchers stayed at the universities, where they could also train new scientists and engineers (Sörlin, 2006). In 1979, the government fixed the policy with a decision that in principle, no further institutes were to be established (though in reality, a few more have been established since). Instead, the idea was that the universities should be the 'research institutes of society'. The year after, the so-called FOSAM-committee (the research collaboration committee, swe. *forskningssamverkanskommittén*), which was to translate this idea into concrete decisions, quite logically gave STU an increased responsibility for university research funding, thus decreasing the funds available for the institutes (Eriksson, 2010). In particular, the amount of money given as base funding decreased.

All in all, this led to a institutional landscape with two strong poles – academy and industry – and little political interest in the research institutes, located as they were 'in between'. While the government funding of university research and the industrial funding of research were both roughly tripled (fixed prices) between 1982 and 1999, the government support to the institutes remained constant during the same period (Sörlin, 2006). Another rather telling example of the political view of the institute sector at this time is that in a 1992 strategy document from the Ministry of Education that supposedly was to guide the coming three government bills on research policy, the term research institute is mentioned only twice and the institutes are given no serious consideration whatsoever. And while a 1991 inquiry into collective research (Statens offentliga utredningar, 1991) was rather positive to the institutes, the preparation of its proposal for presentation in parliament was postponed and a new inquiry appointed instead (Eriksson, 2010).

The institutes were likewise not prioritised in what Sverker Sörlin calls the largest reform of research policy since the 1940s, namely the creation of the wage earner fund foundations (swe. *löntagarfondsstiftelserna*) in the early 1990s. The purpose of these foundations, which had been supplied with money from the dissolution of the wage earner funds³, was to reshape research in Sweden. In spite of this, the foundations generally conformed to the prevailing norm of an academic focus. To what extent this was a deliberate decision remains an open question, but Sörlin (2006) suggests that habit and tradition was important; that relevant actors did not question the by then rather entrenched idea that universities are the performers of publically financed research. Still a few voices, for example from NUTEK (the agency that had replaced STU in 1991) were raised in support of a more multi-dimensional innovation system but during the last two decades of the 20th century these voices did not have enough political influence to shape the policy, which remained academically oriented and with a focus on large-scale programs,

² In Sweden proper, the old universities in Uppsala and Lund were the only two real universities up until the mid-20th century, when the expansion started in earnest. Today there are 14 public universities as well as a few private ones and numerous other institutions of higher learning – this illustrates the magnitude of the development.

³ The idea of the wage earner funds was one of the most contentious issues in Swedish post-war politics. The initial idea, presented in 1976 by the Swedish Trade Union Confederation, was that 20% of the profits of companies with more than 50 employees should be transformed into shares in these companies. These shares would be owned by the wage earner funds which in turn would be controlled by the labour unions, given the latter an increasing influence over all large Swedish companies. The proposal thus amounted to a direct attack on the owners of private capital, and it turned out to be politically impossible to implement it. In 1984, a watered-down version of the funds was finally established, but just eight years later they were dissolved after a right-wing election victory.

perhaps organised into centres of excellence (which apparently was a popular expression in Sweden and elsewhere at the time) (Sörlin, 2006).

It is only in recent times that the pendulum has begun to swing back. Faced with new theories on research policy and a research and innovation landscape that has undergone radical changes since the end of the Cold War, different governments during the early 21st century have made conscious efforts to diversify research funding and research performance, with the first positive (for the institutes) signals arguably coming with the 2001 government bill on research (Eriksson, 2010). One major concern has been the weak link between academy and industry, with a perceived consequence of this being a loss of economic opportunity, as industrial firms are not exposed to the latest ideas and developments (Bienkowska et al., 2010). In light of this, knowledge intermediaries are seen as more important again, and one aspect of the new policy has been to strengthen the industrial research institutes. However, it was not until around 2005 and significantly from 2008 that a policy reorientation that also impacted the funding of the institute sector started to become discernable. As another telling example of the earlier policy attitude towards the institutes, the level of state base support of the institutes in 2005 was, in fixed prices, roughly equal to the level in 1968. During these 37 years, the rest of the innovation system had multiplied in size (Sörlin, 2006).

So in spite of the recent more supportive policy attitude, the road up to the turning point has been rocky for the institutes. In 1996, the KOFI-committee (the formal name was ‘the committee for restructuring and reinforcement of the industrial research institutes’) that had been investigating the institutes presented a report recommending that they should be turned into limited liability companies (Statens offentliga utredningar, 1997). This recommendation was followed, and the institutes were transformed to companies while a new state-owned company, IRECO, was created as a holding company to manage the government ownership. This restructuring correlated with a changing funding situation. Most institutes did get a notable influx of money, mainly from the European Union, during the late 1990s. On the other hand, most institutes lost a lot of public funding during the first years of the new millennium, and it is only quite recently that the sector has started to grow again, now with more dependence on other sources of funding. In 1990, the institute sector was funded to roughly 40% by Swedish public sources. In 2005, that was down to about 30%, with EU money picking up the slack. For at least YKI, the trend has continued, with only 20% of the income coming from public sources in 2010. (Sörlin, 2006; Gergils, 2006; Bienkowska et al., 2010; interview Peter Alberius)

Table 1 below presents a schematic overview of this history, with key events and their implications for the industrial research institutes:

Table 1. Key events in the history of the institute sector. Sources: Sörlin (2006); Eriksson (2010); Kaiserfeld (2010); Petterson (2011).

Time	Event	Impact on IRIs
1940-1945	Inquiry of the Malm committee; establishment of the first IRIs	Starting point of the sector; institutes should perform basic research; collective funding model
1967-1968	Industrial research inquiry; establishment of STU; increased state steering of technical research	Emphasis on applied rather than basic research; initially increased funding; collective funding provided through three-year framework agreements between STU and industry associations
1975-1980	Policy reorientation; universities should be 'research institutes of society'; FOSAM-committee report (1980)	Less funds available for the institutes; decline of political support for IRIs as universities become more and more important
1991	Inquiry into R&D for industrial development and collective research	No effect, preparation of proposals postponed
1993-1994	Establishment of the wage earner fund foundations to help reshape the research system	No significant effect; foundations generally conformed to the existing academic focus
1996	KOFI-committee report	New funding model; institutes are turned into companies; first increased and then after 2000 significantly decreased funding
2001-2010	Another reorientation of policy; first positive signal in government bill on research in 2001; first real changes in government bill on research 2008	Increased political support for the institute sector; first positive policy signals in 2001; significantly increased funding after 2009

To summarise the table, three phases are discernible. In the first phase, roughly between 1940 and 1975, the institute sector was created as a way to support state-desired technical research and during which the institutes, while still performing only a small share of the nation's total technical research, generally had political support and were able to grow. In the second phase, 1975-2000, the university sector came to dominate the Swedish science policy, leaving the institutes with little support and declining levels of state funding. Finally, during the last decade a reorientation of the science policy has been ongoing, with renewed support and increased funding levels for the institute sector.

2.1 The Swedish institute sector today

As of today, most industrial research institutes in Sweden are organised into a network that uses the brand name RI.SE (an acronym for Research Institutes of Sweden). RISE (formerly IRECO) is

also a holding company that organises the government co-ownership of the research institutes and collaborates with the industrial owners. The RISE network today consists of 19 different institutes.

These 19 institutes can be subdivided into three rough categories (Bienkowska et al., 2009) – these are however not ‘official’ categories, and there can be overlap, with not every institute clearly fitting into one of them. The first category consists of ‘traditional’ institutes, traditional in the sense that their work is focused directly on supporting a particular industrial sector. This is the most common kind of institute in Sweden and was historically the dominating type. The second category consists of so-called service institutes. These are not oriented towards a specific sector but rather provide certain general technical services to all sectors. Finally there is a category of institutes who are oriented towards scientific rather than industrial sectors. Their work is often somewhat less directed towards the solution of immediate practical problem, and rather strives to achieve technology push effects by doing a bit more basic research, though in most cases applications are also central to their work (in particular in recent years). This latter category is also the one to which YKI belongs.

2.2 The Institute of Surface Chemistry

As mentioned, the Institute for Surface Chemistry (swe. *Ytkemiska institutet*, YKI) belongs to the group of scientifically oriented institutes. The institute is situated on the campus of the Royal Institute of Technology in Stockholm, and its area of work is applied surface chemistry and colloid chemistry research. Industrial customers come from a wide range of fields – pharmaceuticals, biotechnology, the food industry, pulp and paper, to name a few. As of today, research at YKI is organised into four different sections: Forest Products, Life Science and Chemical Industries, Materials and Coatings, and Fundamental Surface Science.

The history of YKI goes back to 1963, when it was initially founded within the Academy of Engineering Sciences as the Swedish Laboratory of Surface Chemistry, as the Academy had been convinced that in particular the pulp and paper industry was in need of surface chemistry expertise. These developments owed much to the networking of the highly regarded Finland-Swedish chemist Per Ekwall, who became the first director of the laboratory (Stenius, 2007).

After Ekwall’s retirement in 1968, the laboratory developed into a regular industrial research institute with collective funding, first from Swedish companies and then during the 70’s also from companies throughout the Nordic countries, in addition to the state funding. The internationalisation later continued and today the institute has industrial sponsors and clients from many different parts of the world. Like the other institutes, it was transformed into a company in the early 2000s (January 1, 2001 in this case) and since 2006 it is a daughter company of SP Technical Research Institute of Sweden. SP is in turn wholly owned by RISE and thus by the Swedish state. Joining SP, an institute of a different kind and with rather different traditions and styles of working, has had a number of impacts on YKI. Exploring these is beyond the limitation of the present study, but it seems fair to say that becoming part of SP has been an important turning point for the institute.

This has only been a small taste of YKI, to give the reader a first introduction to the organisation that this study aims to describe and analyse some aspects of. The story of the institute and how its knowledge production was affected by the events described above will be picked up in chapter 5. Before that, the theoretical framework and the research strategy and methods of the study will be presented.

3 THEORETICAL FRAMEWORK AND RESEARCH QUESTIONS

The purpose of this chapter is to link the study to existing work within the fields of research policy and knowledge production, in order to introduce the academic debates it wants to contribute to and to create a theoretical framework that can form the basis for the formulation of research questions. It will begin with an introduction to a literature emphasising the changing nature of knowledge production in contemporary society, a process well known under headings such as the 'Mode 2' of knowledge production (Gibbons et al., 1994) or the 'triple helix' of university-industry-government relations (e.g. Etzkowitz & Leydesdorff, 1998). The Mode 2 thesis will be discussed at some length, and an argument will be made that for all its limitations, it does illustrate the relevance of the present topic and it can also be employed to create entryways into the topic of knowledge production. Following this, the notion of scientific 'struggles for relevance' will be presented, along with an introduction to some work on basic and applied research, and on the so-called 'linear model' of innovation. Finally the research questions will be motivated and formulated.

3.1 Changing knowledge production

During the last couple of decades, there have been a number of claims to the effect that new forms of knowledge production are emerging alongside traditional, discipline-based academic research. A review article by Laurens Hessels and Harro van Lente (2008) identifies eight different conceptual frameworks that are all employed to describe or prescribe changes in the way knowledge is produced and evaluated. Of these eight, by far the most influential has been the Mode 2 concept (other well-known approaches include for example the triple helix theory (Etzkowitz & Leydesdorff, 1998) and the idea of 'post-normal science' (Funtowicz & Ravetz, 1993)), as described by Michael Gibbons, Helga Nowotny, and colleagues in their highly influential work *The New Production of Knowledge* (NPK), first published in 1994 (Gibbons et al., 1994). In this section, the notion of Mode 2 knowledge production will be presented and discussed.

More specifically, the section is structured around three parts. Firstly, some indications of the influence the Mode 2 thesis has had on STS and research policy work will be presented. As will be shown, this influence is so vast that the present study, with its similar topic, cannot avoid engaging with it. Secondly, a summary of the content of NPK and its follow-up book, *Re-thinking Science*, will be given. Thirdly, some of the criticism that has been offered of the Mode 2 thesis will be briefly presented. In relation to this, it will be discussed if and how the notion of Mode 2 can still be useful and relevant for the present work.

3.1.1 Mode 2: *The new production of knowledge and Re-thinking science*

Of all the theories from the last few decades that describe changes in the way knowledge is produced and research is situated, the notion of the Mode 2 of knowledge production first launched in the 1994 book *The New Production of Knowledge* (Gibbons et al., 1994) has exerted the most influence both on research policy scholars and research policy makers. In particular the first category have taken the idea to heart; Hessels and van Lente (2010) found almost 1900 citations in a Scopus search from mid-2010, with the number of citations rising from year to year at least up to 2008. A strong majority (see also Hessels and van Lente, 2008) of these papers treated Mode 2 as an accepted account of ongoing changes. This says something about the extent to which the concept has been taken up. Another example of the impact of this work can be found in the study by Ben Martin and colleagues from the department of Science and Technology Policy Research at the University of Sussex (2011), who devised a method of analysing STS handbooks to identify central works in the field. On their list of the top 20 most important contributions to STS, NPK is number 13, ahead of such classic works as Harry Collins'

Changing Order, Trevor Pinch's and Wiebe Bijker's *The Social Construction of Facts and Artifacts*, and Bruno Latour's *The Pasteurization of France*. Even though this cannot uncritically be taken as a correct appraisal of the value of the book, it nevertheless illustrates that it has had a profound influence. This influence means that a study such as this, also dealing with recent changes in knowledge production, hardly can avoid engaging with the Mode 2 thesis.

The main thesis of *The New Production of Knowledge* is that a new knowledge production system is emerging alongside the traditional form of discipline-based academic research (Mode 1). Made possible by mass access to education, by new communication technologies and by increasing globalisation, this new form is socially distributed, much more heterogeneous and focuses on producing knowledge in an application context. The book vacillates a bit on the matter of whether or not Mode 2 will become dominant or even assimilate Mode 1, but it does make clear that the emergence of Mode 2 will have a profound impact on the structure of science systems and of knowledge production in society. It also appears to claim that this emergence will affect all of science and technology, as well as the social sciences and the humanities.

The authors identify five main attributes of Mode 2 which are used to illustrate more precisely how it differs from Mode 1:

- Mode 2 science is performed in a *context of application*
- Mode 2 science is *transdisciplinary*
- Mode 2 science is characterised by *heterogeneous practice*
- Mode 2 science is characterised by *reflexivity*
- Mode 2 science is subject to *novel quality control*.

Knowledge production in a *context of application* refers to work that is directly related to some particular area of practical application. This differs from Mode 1, in which what guide the production of knowledge are not matters of utility but rather the norms and codes of practice of a particular academic discipline. However, this does not imply that Mode 2 is equivalent to applied research as opposed to Mode 1 basic research. The context of application rather refers to the total environment of knowledge production, encompassing everything from problem selection and methodology development to research outcomes and the utilisation of the results. In Mode 2 it makes no sense to use traditional terminology of e.g. application of research or technology transfer, because there is no longer any such gulf that needs to be bridged. The distinction between basic and applied, between the context of development and the context of use, disappears.

The next attribute, *transdisciplinarity*, refers to a kind of merger of different disciplinary approaches (theories and methods) to solve problems, something that does not happen in Mode 1. It is different from interdisciplinary work in that it is more dynamic and leads to closer integration – the new knowledge might not easily be reduced into any of the old disciplines. In fact, transdisciplinary work does not necessarily derive from pre-existing disciplines at all, nor does it necessarily contribute to the forming of new disciplines. It is creative work, often of a temporary nature, that relates to the management of different approaches to problem solving, driven by the context of application.

The *heterogeneous practice* of Mode 2 research has to do with a diversification of the sites of knowledge production. Mode 2 knowledge is not just produced in academic departments or industrial research labs, but in a plethora of different sites (government agencies, think-thanks, spin-off companies, consultancies, etc.) linked through new networks of communication. The borders of research communities become more open and both their internal and external dynamics change.

Reflexivity has, shortly stated, to do with an increased capacity to incorporate multiple views on the production of knowledge, with researchers becoming more sensitive to the social consequences of their work. The last point does not simply amount to an increased awareness of e.g. traditional research ethics, but involves a radical reconceptualisation of research accountability. Mode 2 research is not an objective investigation of the natural world that ought to be performed according to some specific guidelines (often determined by some outside expert, e.g. an ethicist). It is rather an endless ‘conversation’ between researchers and their subjects. The reflexivity is inherent in this conversation.

Finally, the *novel quality control* of Mode 2 goes beyond the traditional academic peer review. Additional criteria, e.g. political, economical or social ones, factor into judgments about whether or not something is good research. This depends both on the fact that in a context-driven, transdisciplinary environment, it is simply not possible to clearly identify one’s peers, but also on the fact that in such a research environment, it is unreasonable to expect that there can exist clear and unambiguous criteria for the quality of the knowledge produced. In Mode 2, there must be multiple dimensions of quality, with all that this implies for research policy and funding.

These five attributes of Mode 2 knowledge production amount to a highly radical thesis on the nature of research in contemporary society. If the authors are right, traditional structures will increasingly come under heavy pressure to adapt to this new environment – those that do not adapt will instead have to struggle to be able to maintain their old identities. It is not surprising, then, that the book got a mixed reception. The argument was severely criticised on a number of points; this will be returned to below. Yet it was also embraced: as Hessels and van Lente (2008; 2010) have shown, most citations of the book treated it as an accepted account of ongoing changes, which indicates that the description it provided was recognisable to many people (whether or not everyone who embraced Mode 2 were fully sensitive to the complete post-modern thesis is another matter).

In 2001, seven years after the publication of NPK, three of its authors – Helga Nowotny, Michael Gibbons and Peter Scott (2001) – published a second book, *Re-thinking Science*, in which they elaborated and expanded the argument. Partly this book was a response to the criticism that NPK had become subject to; it was also an attempt to clarify the argument and to develop it further. Perhaps the most apparent addition is the introduction of some social theory to underpin the case that is made and to more clearly relate it to other post-modern literature. It is also made apparent that the Mode 2 development should not be understood as an autonomous phenomenon, isolated to the world of science. In fact, it encompasses all of society: what we see happening is an increasing transgressiveness of what Nowotny and her colleagues call the great sub-systems of modernity: State, Market, Culture, Science (Nowotny et al., 2003). The shift towards Mode 2 takes place as these categories become more and more fuzzy and start to overlap each other. In other words, society as a whole is changing in a post-modern fashion, and science changes as part of society. The bi-directional relationship between science and society is also emphasised. With a well-known phrase it is made clear that while modern science always has spoken to society, society now has started to ‘speak back’:

In modern times, science has always ‘spoken’ to society; indeed science’s penetration of society is close to being a defining character of modernity. But society now ‘speaks back’ to science. This, in the simplest terms, is what is meant by contextualization. (Nowotny et al., 2001, p. 50).

Science, as it were, is to various degrees contextualised socially – present in a society that demands and exerts control of its processes and results. The notion of contextualisation serves to clarify a point that was often misunderstood as presented in NPK – Mode 2 does not entail a

move from basic to applied knowledge production, but rather describes the blurring and eventual disappearance of that and other demarcation lines as the borders between science and the rest of society are transcended.

In many ways, the addition of the second book makes the argument both more complex and more coherent at the same time. Its impact was not nearly as profound, presumably because it is less accessible and far from as easy to find catchphrases in. Most of the Mode 2 debate remains focused on NPK, and most of the criticism directed towards the notion of Mode 2 focuses on the argument as presented in that book. Some of this criticism and how it affects the use of Mode 2 in the present thesis will be discussed below.

3.1.2 Discussion

It should at first be stated clearly that the purpose of this study is not to seek to confirm or reject any particular general theory about knowledge production, but rather to explore and try to understand processes of knowledge production in one particular case. The general theory of Mode 2 is drawn on here because it illustrates the relevance of the topic – this is a discussion that is still very much ongoing in academic circles – and because it is able to provide possible entryways into the concept of knowledge production. The aim of this section is then to shortly argue for the relevance of the theory and the topic, and show how the former can provide a way to approach the investigation of my case.

First the relevance. It is clear that discussions about changes in knowledge production are still very much ongoing. This is illustrated for example by the citation data that Hessels and van Lente present, or by the fact that almost an entire recent issue (vol. 6, no. 1) of the journal *Science, Technology and Innovation Studies* was dedicated to a discussion of the Mode 2 concept. More generally speaking, Mode 2 and similar theories remain discussed because understanding knowledge production, and understanding a science and innovation system that many perceives to be in flux, remains very relevant in a contemporary society in which scientific research and technological innovation are seen as crucial for economic development and, ultimately, the welfare of people. Mode 2 is, as shown above, central to this debate, and it is thus impossible for this thesis to not engage with it.

In spite of its impact, it is not uncontroversial to employ the Mode 2 theory in the construction of a theoretical framework. It has been the target of heavy and in some respects devastating criticism. This criticism mainly focuses on three different points:

- The lack of empirical data to back up the claims made by Gibbons, Nowotny and their colleagues
- The conceptual weaknesses of Mode 2
- The perceived conflation of description and ideology present in NPK

Very briefly stated, the first point criticises that there is no clear, unambiguous empirical evidence for the Mode 2 theory, neither in NPK and *Re-thinking Science* nor in any of the follow-up studies performed (e.g. Hicks & Katz, 1996; Godin & Gingras, 2000; Gulbrandsen & Langfeldt, 2004). The second point does not discuss empirical matters (indeed authors formulating this kind of critique often concedes that there are ongoing changes of research systems across the world), but rather criticises conceptual weaknesses in the theory: the way the attributes, in particular transdisciplinarity, are defined (Weingart, 1997); the fact that the theory does not account for differences between different parts of the science system (Weingart, 1997) or between different national contexts (Weingart, 1997; Shinn, 2002); the fact that its internal coherence (i.e., if the attributes really make up a coherent ‘mode’ of knowledge production) is doubtful (Rip, 2002); and that its historical description, in particular as regards the Mode 1-Mode 2 distinction, is flawed (Rip, 2000; Roberts & Shaffer, 2007). The third point argues that

while posing as a descriptive account, NPK is really a normative appeal for the changing of the science system, replacing theory and data with political commitment (Godin, 1998; Shinn, 2002).

All these points are rather strong and taken together, they are quite devastating for Mode 2 as a theory. It clearly has significant weaknesses, particularly on a conceptual level, and because of this it is not uncontroversial to employ it as part of a theoretical framework. However, a theory can be used to inform or structure an investigation without necessarily being fully embraced. In this study, Mode 2 is neither uncritically accepted as a correct descriptive account, nor is itself taken as the subject for an empirical investigation. It is rather used to demonstrate the relevance of the research field and to provide a starting point for an investigation into the abstract notion of knowledge production. In many ways, this approach is close to a reading of NPK as more of a manifesto and less as a scientific theory (in line with the suggestion of Hessels and van Lente (2008)), i.e. considering the book to be a declaration of some basic ideas, and to point out a way to proceed, rather than providing a fully developed theory to reject or confirm (the word manifesto should not be taken to imply that this thesis fully accepts all the ideas expressed in the book).

With this approach, where the purpose is not to seek to confirm or reject Mode 2 as a general theory of knowledge production, but rather to explore and try to understand processes of knowledge production in the particular case of YKI, the criticism presented above is no serious problem. To restate the caveat again: the study will not assume that the expected changes that will be studied are completely in line with any theory or form some sort of integrated whole. Instead of assuming that all five attributes together make up a new mode of knowledge production, it wants to investigate how the dimensions of knowledge production that a few of these attributes highlight have taken shape in one particular case. Exactly how this will be done is returned to in section 3.5 below. Before that, two other parts of the theoretical framework will be presented.

3.2 Struggle for relevance

It should be clear from the above that in spite of the problems with the Mode 2 notion, it seems established that research systems all over the world are changing. These more or less radical changes give rise to a follow-up question: what happens to research institutions that come under pressure from such changes? An interesting approach to this question is to consider that such institutions have to 'struggle for relevance'. This term was first coined by Arie Rip (1988) to refer to an effect of the development of new kinds of mission-oriented institutions in the 1970s and 1980s, namely that it gave rise to struggles of relevance of science, above or on top of struggles for funding. The notion was picked up and generalised in the PhD thesis of Laurens Hessels (2010), whose work will be introduced here.

The general aim of Hessel's study was to understand how university researchers from three different disciplines in the Netherlands struggle for relevance. Relevance is taken to mean the possible benefits of science to society, and Hessels argues that researchers (he considers the struggle both on the level of individual researchers and on the level of collectives, e.g. research organisations, but is focusing mostly on the former) must make sure that their work in one way or the other has such relevance. This is not straightforward. Not only can the struggle for relevance conflict with other personal or organisational values, but furthermore, the meaning of relevance is not fixed. What is considered relevant is a product of social interaction, so scientists, together with other stakeholders, are also engaged in a struggle *over* relevance, in which they try to influence the dominating norms and standards. It might be added to this that there can also be struggles *with* relevance, in which the struggle is not primarily antagonistic with respect to other values or other stakeholders, but rather is an individual or organisational struggle to understand and conform to the existing standards of relevance. A further clarification that can

be added is that the struggle for relevance is not always about making sure that one's work actually is relevant according to some standard – in interaction with policy makers and potential financiers it can also be about making it *appear* relevant. At any rate, Hessels shows how struggles for relevance have generally become more and more intense from the 1970s and onwards, and that they have taken on different characteristics in different scientific fields.

This work corroborates the idea that researchers and research organisations actively have to orient to prevailing norms and standards of knowledge production and illustrates ways in which this can happen. It can be assumed that the struggle for relevance of an industrial research institute such as YKI is bound to be complex and interesting, situated as they are in somewhere in between state, industry and academia (and possibly other institutions, e.g. the European Union, as well), all presumably with their own ideas about relevance.

Hessel's dissertation is highly interesting in many ways, but it is beyond the scope of the present thesis to present his work in more detail. Its primary importance for this study lies in the conceptualisation of scientific work as including a struggle with and over relevance, and the demonstration that at least in the Netherlands, such struggles have become more and more important in a changing research environment (Hessel's elaboration of the struggles for relevance as part of the credibility cycle described by Bruno Latour and Steve Woolgar will not be used in the present thesis). This conceptualisation will later be used in the analysis, in which the struggle for relevance concept will be applied to the findings of study to help understand the developments at YKI.

3.3 Basic and applied science and the linear model of innovation

Struggling for relevance has to do with on the one hand relating to existing standards, and on the other hand with trying to influence those standards. Considering the case of the industrial research institutes, the historically most important standard they have had to relate to has most likely been the dichotomy of basic and applied research: research driven solely by a desire to understand the world, and research aiming for results that can be put to use. There is a wide body of literature discussing these two concepts and it is not possible to give a complete account here. The focus will be on a brief historical review of how these concepts, and the relationship between them, have been understood and used in Western science policy (or not, as a famous counterargument by David Edgerton, which will also be presented, would have it), on how they have been used in formulating policy for the Swedish industrial research institutes, and on work demonstrating how scientists and policy makers can pragmatically employ these concepts for their own purposes.

At first it is however necessary to make some preliminary remarks on the definitions of basic and applied science. These terms (and other similar ones, such as 'pure' or 'fundamental' science or research) have a long history, with the concept of pure research apparently dating back to 1648 (Godin, 2003) and the idea of a distinction between pure and applied having existed since antiquity (Stokes, 1997). The meanings of the concepts, and the way in which they are used, have changed over time. These historical struggles with and over them cannot be presented in detail here, but there is good literature available (e.g. Kline, 1995; Godin, 2003). In his study of the concept of R&D and the taxonomies of research, Benoît Godin (2005) also provides a handy summary of a number of different definitions of the concepts (sometimes other categories of research are identified as well). Generally, the distinction is based on applied research being research that aims toward a specific practical objective, while basic research have no such pre-conceived practical goal. The definitions that seem to be quoted most often in contemporary literature come from the so-called *Frascati Manual* (a document containing conventions for surveying R&D) of the OECD, and read as follows:

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Applied research is also original investigation to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. (OECD, 2002, p. 30)

Basic research is in this document also further demarcated into ‘pure’ and ‘oriented’ basic research, with the latter being carried out with the expectation that it will produce knowledge relevant for current or expected future problems or possibilities, while still being basic in the sense that it has no *particular* application in view (similar demarcations of basic research can be found in many other sources as well, the most famous arguably being Donald Stokes’ (1997) concept of use-inspired basic research). Of course, considering these definitions, and in particular their sub-parts, give rise to the question if the demarcation makes practical sense at all, or if it is just a statistical invention? Is it not often the case that the two are intertwined, and cannot basic research yield applied results, and vice versa? These are important questions, and they will be returned to in a later part of this thesis.

To then begin with the historical review, a conventional way to look at post-war research policy in the Western hemisphere is to divide it up into three rough phases, which following terms used in NPK can be named “policy for science”, “science in policy”, and “policy for technological innovation” (Gibbons et al., 1994, p. 158). During the first phase, whose main ideological proponent is considered to have been American engineer, administrator and policy advisor Vannevar Bush, the focus was on basic science⁴. In *Science, The Endless Frontier* (1945), Bush’s report on the role of post-war science, he made it clear that in his view, the economic development of a nation was dependent on the domestic production of fundamental knowledge, i.e. basic research. Calling basic science the ‘pacemaker of technological progress’, Bush argued for what has become known as the linear model of innovation: that basic, undirected research is the necessary foundation upon which useful application can later be built, and that this works in a strict sequence, so that basic research needs to precede applied research:

Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science. (Bush, 1945, webpage)

Of course, Bush did not invent this way of thinking (which has long history and, as Godin (2003) has argued, might even be the spontaneous philosophy of scientists), but he was arguably the first author to produce a formal formulation of it (Godin, 2003). In accordance with this understanding, in the ‘policy for science’ phase the focus was on enabling the growth of basic science while at the same time shielding it from outside influences, leaving the choice of problems up to the individual researchers.

⁴ Although Bush, probably thanks to the ideological clarity of his report (and possibly also to the positive reputation of the Office of Scientific Research and Development where he worked – see Kline (1995)), is often credited as the initiator of this kind of science policy in the United States, his suggestions were in fact not particularly influential with policy makers. J. R. Steelman, who two years later wrote another report for president Truman, deserves as much credit. (Godin, 2003)

In the 1970s, a shift in policy is discernible (a famous example of this new view is the well-known British Rotschild report, published in 1971), from a focus on good science as a policy objective in itself to science as a means by which other policy objectives can be achieved. This implies that a more active science policy was called for, but in spite of this, there was still not much attention given to *how* exactly science could contribute to society. That came with the third phase, driven by the economic downturn of the late 70s: policy for innovation. This policy phase, which arguably still is the dominant view⁵, narrowed the focus to the role of science in directly contributing to industrial innovation and growth and led to an increased focus on applied science, to the appropriation of more multi-faceted models of innovation, and to a number of new initiatives aiming to strengthen science's contribution to industry. While it perhaps is dubious to map these phases directly onto the Swedish policy developments outlined in chapter 2 (that is, to reduce the developments in the Swedish technical research policy to these more general and international trends of science policy), it is clear that the recent re-evaluation of the industrial research institutes have been driven by something like a more multi-faceted policy for innovation, and it is also plausible that the increased state involvement in the research institutes from the late 1960s relates to a 'science in policy'-view.

The sketch of the three phases above is, however simplified, close to a conventional history of post-war science policy in the West. But not everybody would agree with this history. A well known alternative story, focusing in particular on the role of the linear model, is presented by David Edgerton (2004), who makes the case that the linear model has never really existed as anything but a straw man; as a foil for the more sophisticated argumentation of science and technology scholars, and possibly as a propaganda tool for scientists struggling for relevance. It never dominated policy – that idea comes, according to Edgerton, from a misrepresentation of the content of Bush's report, an exaggeration of its influence, and a lack of understanding of its context.

If the linear model indeed is nothing but a straw man, as Edgerton argues, how did (and do) policy makers really consider the relationship between science and its applications? To fully elaborate this matter is clearly far beyond the scope of this thesis (and it should also be noted that Edgerton's argument remains controversial). What will be considered here is restricted to the available work on how Swedish investigators and politicians conceptualised the issue while considering the establishment of the industrial research institutes in the 1940s. As Ingemar Petterson (2011) has shown, the distinction between basic and applied was important to them, and they often tried to draw a sharp distinction between the two. As noted in chapter 2, an often-expressed principle was that the public funding of the institutes should be used to support basic research, and that public money generally should not be spent on applied research. This is somewhat paradoxical, as it was at the same time established that a clear distinction between the two types of research was impossible to make. Petterson explains that the end result was a highly pragmatic distinction, perhaps more used to sort public and private interests – it was important in particular with regards to publications and patenting – and less related to the actual nature of the performed research.

The general idea behind publicly financed basic research in this context also contains a conception of the innovation process as a whole. Though basic research was sometimes held up

⁵ Though it is questionable how successful this approach to science policy has been: something often mentioned is the 'European Paradox', by which is meant the failure of European countries to translate their scientific output into inventions (and by extension into economic growth), in spite of a number of policy initiatives designed to stimulate exactly such translations. Some commentators can be seen to call for another policy shift, including for example a return to more support for basic science (e.g. Dosi et al., 2006).

as a necessity for applied research, in line with the linear model, the idea that applied research could give rise to the need for basic research (i.e., individual companies doing applied work could come to realise that they needed more basic knowledge, but they would often lack the resources for this – which is where the industrial research institutes were supposed to come into the picture) was also expressed. Petterson concludes that the investigators had a rather interactive understanding of innovation, and that no strong linear model is discernible in their output. He suggests that they were influenced by a weaker form of the linear model (see Balconi et al., 2010), in which basic research retained some primacy but innovation was not considered a strictly linear process, by necessity always proceeding unidirectionally from basic to applied.

These attitudes largely changed around ten years before the start of the present study. As mentioned in chapter 2, the state extended its area of responsibility to include also applied work in the late 1960s, while at the same time differences between basic and applied were downplayed (Petterson, 2011). Maybe this to some extent reflected a new understanding of the nature of research, but again it could also be understood as being a pragmatic way to organise state and industrial roles, with the state now desiring an increased influence.

That the demarcation between basic and applied seemed to include a pragmatic and rhetorical dimension, sorting public and private interests more than describing the actual nature of the research, ties in to the work of Jane Calvert (2006), who studied the issue in a contemporary setting. Using the notion of boundary work (see e.g. Gieryn, 1983), she explored the term 'basic research' and showed that it could fulfil a rhetorical function for both scientists and policy makers that does not necessarily relate to actual research practice. Something can be described as basic science to protect scientists from external demands for applications and patents, but basic science can also be presented as having potential applications in order to secure funding⁶. The work of the term seems to be most important when scientists interact with non-scientists (e.g. sponsors or policy makers). Furthermore, the scientists Calvert interviewed were generally open with this kind of boundary work, and engaged in it with a high-level of self-awareness.

Calvert did not study how the term was related to actual research practice. Though the present thesis also does not concern itself with the details of practice, it is, like Calvert, concerned with how the categories of basic and applied research have been used in different situations, and also how this relates, or is described by researchers as being related, to the production of knowledge (this is also where the idea of a linear model of innovation comes in – as described above, basic research in the industrial research institutes has been linked to linear model thinking, at least in a weak form). It is likely that this is a locally contingent matter, highly dependent on history and context, and is thus something worthy to explore for any local site of knowledge production⁷. And given the centrality of the categories of basic and applied research in the history of

⁶ Indeed, even if one can occasionally find appeals to knowledge for its own sake, by far the most common way to justify basic research is through the use of utilitarian rhetoric. As Maja Fjaestad (2010) has shown, even such a venerable and clearly basic-oriented organisation as the German Max Planck Society motivates their research by expected future applications and/or economic gains.

⁷ A fascinating historical example of the sometimes complex relations between descriptions and knowledge production, which also illustrates the long history of struggles over such descriptions, can be found in Fokko Jan Dijksterhuis' (2007) study of dioptrics in the 17th century. He describes the irritation of Constantijn Huygens when his son Christiaan in a letter was described as a *mathématicien* instead of a *géomètre* (Christiaan Huygens of course was the most renowned European mathematician of his time). This was a distinction roughly corresponding to pure and applied mathematics, but is also carried a social connotation, and as a member of the social elite Christiaan Huygens should have been considered a *géomètre* in spite of the fact that much of his work was of (what today would be considered) an applied nature.

industrial research institutes, it also seems to be a crucial matter if one is to understand the developments at YKI.

3.4 Summary

To briefly summarise the first part of this chapter, its first consideration was the Mode 2 thesis presented by Michael Gibbons, Helga Nowotny and colleagues: one of several theories that assert that the nature of knowledge production in contemporary society is either changing or ought to change. It was demonstrated that this thesis has been met with both acceptance and criticism, and that it remains at the centre of an ongoing debate, thus establishing the relevance of an inquiry into the nature of knowledge production. It was also argued that in spite of the limitations of the Mode 2 thesis as a coherent whole, some of the ideas presented in the book could be helpful starting points from which the nature of knowledge production can be studied. In section 3.5 below these ideas will form the basis for the actual research questions investigated in this thesis.

Even among the critics of the Mode 2 notion, it is most often conceded that the research system is and has been changing – what is controversial is rather the nature and extension of the changes. This gave rise to a second consideration, namely what happens to research organisations that come under pressure from such system changes. Using a concept previously employed by Arie Rip and Laurens Hessels, it was argued that they have to struggle for, over and with relevance. Although such struggles probably are as old as science itself, Hessels demonstrates how they have increased in intensity during the last decades. He does this for the case of the Netherlands, but there is no particular reason to believe that the same development has not taken place elsewhere. The concept of struggles for relevance will return in chapter 5, in the description of the findings and in particular in the analysis where it will be employed to help understand the developments at YKI.

Considering the history and the nature of the industrial research institutes, it was further argued that a very important struggle for them always has been related to the differences between basic and applied research, the third consideration of the section. A brief introduction to these concepts, to their role in science policy and to their role in the establishment of the Swedish industrial research institutes was made, along with an introduction to the work of Jane Calvert, who has shown how scientists use these terms rhetorically; to perform boundary work. It was finally argued that the relationship between the employment of the terms and the actual view of the scientists and organisations that use them most likely is a locally contingent matter that is highly interesting for an empirical investigation. The categories of basic and applied research will recur continuously throughout chapter 5 and 6, in the findings, analysis and discussion.

3.5 Research questions

Having thus established the theoretical framework that will be applied, it is now time to turn to the actual research questions that will be investigated. The notion of ‘knowledge production’ is an abstraction, so in order to investigate it empirically, it is necessary to move from the conceptual level to something that can actually be studied. In the literature, there are two main ways in which this is done: either theoretical claims about changes in knowledge production (such as the five attributes of Mode 2) are operationalised more or less directly (e.g. Hicks & Katz, 1996), or the research questions are derived from implications of the theories (e.g. Godin & Gingras, 2000). In the present case, the research questions will be derived from a starting position of three of the Mode 2 attributes, but given the topic and limitations of the study, the actual questions will be adapted to the case of YKI rather than to an empirical validation of the theory.

To remind the reader of what is going to be achieved by the research questions to be formulated, it seems useful to restate the aim of the study: *To explore and understand processes of knowledge production, and changes in these processes, in the Institute for Surface Chemistry during the time period from 1975 to 2005.* This aim will be achieved through questions formulated from the ‘starting position’ of three of the five Mode 2 attributes: context of application, heterogeneous practice and novel quality control. These three were chosen to enable a focus on certain areas that were considered particularly interesting in relation to YKI. However, to avoid making undue theory-laden assumptions, the attributes were not directly operationalised but were transformed into three focus areas that will structure the rest of the thesis (see table 2 below).

Table 2. Mode 2 attributes and focus areas of the study.

Mode 2 attribute	Focus area	Questions about
Context of application	Basic research and applied research at YKI	Distinctions between basic and applied, role of these two concepts at YKI, their use by YKI researchers
Heterogeneous practice	Heterogeneity of YKI knowledge production	External connections of YKI, its role in the research system, diversity of its funding and research partners
Novel quality control	Quality control at YKI	Quality control measures in use at YKI, status of traditional academic norms, YKI researchers’ understanding of good research

The ‘main’ focus area is the struggle over basic and applied research. This is arguably both the theoretically most interesting area, and the area most central to YKI itself. In addition to this, heterogeneity and quality control will be studied. To lay the foundation for the examination of the three focus areas, the study will also explore a few general questions relating to the case itself, as follows:

Which and what kind of actors and institutions have been involved in the knowledge production of the institute? What were their roles? How did the institute itself develop? Has its role changed during the study period?

Before proceeding to the focus areas, it can also be mentioned that there is a general structure to the research questions. On the one hand, they deal with what might be considered relatively uncomplicated facts (e.g. the number of research partners and variation of this number over time) and with the ‘official’ output of YKI (which will of course be analysed as source material, not taken as objective truth). On the other hand, the study also wants to get a little closer to the actual production of knowledge, to if possible contrast internal viewpoints on this production with what was projected outwards. To some extent, this structure is also reflected in the empirical division between archival sources and interviews.

The first of the actual focus areas derives as mentioned from what in NPK is called context of application, but to avoid making assumptions about the development of such a context at YKI, the questions will more generally relate to the distinction between, and the struggle over, basic and applied research. Of course, concerns about applicability have always been central to the industrial research institutes. Their very existence is motivated by the performance of industrially relevant research. Yet whether or not research considered industrially relevant is

always of an applied nature is less clear. As demonstrated above, there have been many different takes on the nature of the innovation process, which has been conceptualised both in a linear and more non-linear fashion, with a 'weak' linear model apparently guiding the establishment of the first post-war industrial research institutes. The general political trend since the mid-1970s or so can probably be said to be going towards less linearity, so on that account more applied research might be expected. On the other hand, more factors are likely to come into play, not in the least the preferences of industrial companies that, depending on their own capabilities, might or might not desire more basic work. To complicate matters even more, there is currently a noticeable trend in STS to downplay differences between basic and applied (see Roll-Hansen, 2009), something that also recurs in the NPK argument that in Mode 2, the distinction between basic and applied will disappear. Furthermore, it must not be forgotten that the two categories can be employed to perform rhetorical functions as well and the image projected outwards might not be a completely accurate reflection of the self-image (for example actors might emphasise the basic or applied nature of their research to e.g. secure funding, while themselves considering such categories less relevant).

To straighten out this for the present case, it is particularly interesting to know more about how the categories have been used at YKI: what role they are given in the institute's published descriptions of its research and if and how this has changed over time, and how the researchers at YKI themselves understand and have used the categories. The first set of research questions thus concerns itself with the navigation between basic⁸ and applied:

How can it, in the output of YKI, be distinguished between work that is basic and applied? If such a distinction does make sense, which trends of increasing or decreasing basic or applied research performed by the institute can be discerned for the study period? How can these trends be explained? Also, how have the actors and researchers at YKI themselves used these categories; what is their image of YKI-performed research?

The second focus area takes the attribute of heterogeneity as its starting point. Of all the claims in NPK, this seems to be the least controversial. Most scholars readily acknowledge that the research landscape has expanded (as a more diverse set of research performers and funders have gotten involved), even if they dispute the consequences of this expansion. Nevertheless, it remains interesting to explore in the context of the research institutes, which in a changing research systems presumably have had to struggle to find a stable position. Many of them have a history of knowledge producing relationships with academics and universities – joint research projects, shared resources, employees spending time in both locations, etc., with the relationship between YKI and the Royal Institute of Technology arguably being rather close compared to some other institutes (Eriksson & Ericsson, 2005). The relationship with the industry, on the other hand, has (very generally speaking) tended to be more of a technology transfer link, in which the role of the institutes have been more to facilitate connections and diffuse knowledge from the academy to the industry, or producing specific knowledge for industrial purposes, rather than actually producing knowledge jointly with industrial companies.

Those are the traditional relationships. If theories about increasing heterogeneity are correct, one would expect to see that the institutes lately have forged new connections outside of the old ones: to other universities, spin-off companies, government agencies, external consultancies, etc. Such changes might also result in, or require, a changed self-image of the institute and its role in the innovation system. Whether or not this has happened, and how individual researchers at YKI

⁸ Basic research does not have to be completely unrelated to possible future applications, however (there is probably very little such research at YKI). Following e.g. Donald Stokes (1997) or the Frascati Manual (OECD, 2002), the existence of oriented or use-inspired basic research is acknowledged.

have experienced developments in this area, is what the second set of research questions explores:

How has the knowledge production of YKI changed with respect to heterogeneity (in the sense of involving more or less different partners) during the period of study? How have the traditional relationship with universities and with the industry, and the institute's general role in the innovation system, changed? How do the actors and researchers within YKI consider the role of the institute?

The final focus area derives from the novel quality control attribute of Mode 2, i.e. the struggle with good research and over what should constitute good research. A lot has been written on this, with opinions going in divergent directions. First there is the theory that the criteria for determining what good research is are expanding to include factors beyond classic academic peer-review. This is the view expressed in NPK and in other related work (e.g. Hemlin & Rasmussen, 2006). The normative version of the claim – that quality control should expand – is also the view taken by at least one government inquiry into the work of the research institutes (Statens offentliga utredningar, 1991). On the other hand, actual evaluations of this claim seem to indicate that not much has been changing (e.g. in the Norwegian case studied by Gulbrandsen & Langfeldt, 2004) or that the trend is even the opposite; towards an academisation of the publication culture (which might or might not reflect a change in the norms of quality control)⁹. And as Kaiserfeld (2010) shows, the co-existence of academic and industrial norms of evaluation has a long history in the research institutes. It does not seem entirely far-fetched to guess that the balance between the two has shifted over time.

Exploring this entails asking questions about how YKI has measured the quality of its work and if and how this has changed. In particular, it is of interest to study how the institute have related to the traditional practices of reporting scientific activities. This connects to the self-image of YKI and its researchers – relevant questions are what they think constitutes good research, and how they have experienced measures of quality in their daily work at the institute. The aim of the third group of research questions is thus to try and make sense of this:

How has YKI measured the quality of its work during the study period? What trends can be seen in the employed measures? In particular, what has been the status of traditional academic quality control (i.e. peer-reviewed publications) during the study period? How do actors and researchers within YKI consider quality control? How, in their experience, has quality been measured at YKI?

Together, these three focus areas will give a broad overview of some of the dynamics of knowledge production within the institute. The answers to the outlined questions will hopefully both provide useful knowledge about an area that as of yet is not well known, and be able to function as the foundation for further studies.

⁹ Something that could relate to this is the point that is made by Wendy Faulkner and Jacqueline Senker (1994) in their study of public-private research linkages: academics outside of the academy might themselves strive to keep in contact with the 'ivory tower' by e.g. publishing themselves in academic journals. This does not necessarily reflect a quality control issue for the organisation in question, though there would presumably be interplay.

4 RESEARCH STRATEGY AND METHODS

Having established the theoretical framework and the research questions derived from this framework, this chapter will describe how these questions were investigated. This includes both some general remarks on the choice of a research strategy and a more detailed account of sources and methods used.

4.1 Research strategy

To study the research questions, empirical methods as well as a general strategy of their use are needed. Here it might first be useful to consider the choice of methods used in earlier studies. There are essentially two main routes taken by researchers investigating the dynamics of knowledge production: interviews (e.g., Gulbrandsen & Langfeldt, 2004) and bibliometric analyses (e.g., Hicks & Katz, 1996). Such studies normally lack a historical focus, aiming instead to study knowledge production by a snapshot of a current state of affairs (that is, aiming to for example evaluate the hypothesis that the innovation system today has taken on a Mode 2 form). To this can then be added the route often chosen for historical studies of the industrial research institutes, namely the qualitative study of relevant archive material (e.g., Larsen, 2010; Bergquist & Söderholm, 2010). For the present study, a combination of interviews and studies of archive material was used.

To study the history of knowledge production within a research institute, one possible starting point is to study output like the annual reports or the research programs of said institute. This output gives access to a kind of ‘official’ image of the institute and its development, including both more or less straightforward facts as well as a kind of narrative version of the development across the study period, which can form the basis for an analysis.

A basic methodological assumption of the study was, in addition, that it would be beneficial to complement the work with the archive material by performing interviews. By getting the YKI actors’ own perspective, it would be possible to first of all fill in the blanks that one can expect to have left even after a review of the archives, but perhaps more interestingly, it would also be possible to go behind the more formal output of the institute, to say something about the actual production of knowledge as experienced by those who produced it. Combining archival sources and interviews is likely to produce a fuller picture than either method could have achieved alone. Furthermore, performing interviews with older employees helps to preserve personal experiences of the construction and development of this particular research environment, experiences that would otherwise eventually be lost. This is considered to be something intrinsically valuable¹⁰.

Taken together, archive material and interviews were thus considered to be a good way to approach the research questions. A description of the interview and of the sources used follows below. The limitations of this research strategy, and what it implies for the study, will be considered in chapter 6.

4.2 Archival sources

The archived YKI output included in the study focuses on material that can be considered external, that is, material provided for an audience existing also beyond the institute itself.

¹⁰ This links up with a previously used method at the Division for History of Science and Technology at the Royal Institute of Technology – where this thesis is written – of performing so-called witness seminars in which actors’ experiences of historical events and developments are recorded and preserved. It seems to this author as a very important – and appealing – part of historical research.

Available material of this kind was annual reports, research programs and newsletters. What is not included in the study is internal documents, such as meeting protocols or internal memos. This delimitation was made because of constraints on the time available for the thesis work and because unlike the material actual used, most other documents were not already collected and organised into time series. Further discussions of the limitations of the material and the consequences of this for the study will be found below as well as more extensively in chapter 6.

The most important part of the included material is the annual reports of YKI. These were studied for the entire study period. To provide further context, a few older reports were also considered, going back to the 1970/71 business year¹¹. Both the content and the format of the reports vary quite a lot during the period of study, but all provide both a narrative of the year's work at the institute and some statistical and financial data about the year. Generally, the yearly reports are dominated by a quite technical presentation of the research done at the institute. Other recurring parts are the introduction by the director of the institute, a presentation of the external contacts, organisation charts, and lists of publications, events and funding companies.

These yearly reports thus provided both facts about YKI (e.g., number of involved companies, levels of funding for different research areas or the current organisational structure) and an official presentation of the work, i.e. the image that the directors of the institute wanted to project outwards (the latter was considered on two levels – besides the actual discourse, it was often interesting and revealing to consider changes in layout, e.g. how much space was allocated in different years to describe research describe as basic and applied, respectively). This outward image was interesting for example with respect to how much emphasis was placed on basic versus applied research, and they were also able to provide an image of the external relationships of the institute, thus contributing to answering questions of heterogeneity. Quality control issues are only rarely mentioned explicitly in the yearly reports, however some indication can be found simply by considering what was included – that is, how YKI tried to convince other actors of the quality of their research.

A second main source was material filed under the heading of 'research programs' – strictly speaking not one type of document, but rather several related types, including three-year framework programs, yearly research results and research programme budgets. Mostly this had to do with how YKI has chosen to organise the documents; the available data was more or less the same year-for-year. This material was also considered for the entire study period. Also related to this category are a set of small brochures called 'Research at YKI', which were published from 1993-2000 and contains a brief introduction to the research program of the institute. Most of the content in the research programs is of a highly technical or financial character, and as such was not directly relevant for the project. The analysis focused on the introductions and research motivations, as well as the layout and partitioning of the documents. This was again able to provide a number of clues as to how the basic/applied research dichotomy was managed (or struggled with), as well as giving an image of the external research connections of YKI. Quality control issues are rarely in focus, however.

A third source used was copies of YKI News (at the start of the study period it was published in Swedish as *YKI-nytt*; from 1992 and onwards an English version has been produced instead), the newsletter of YKI, sent to member companies and other interested parties. This material was available from 1981 to the end of the study period. Like the other two types of source materials, these newsletters are dominated by a presentation of research performed at YKI. It also includes information about personnel changes, presentations of equipment and other subjects of less

¹¹ Up until 1997, the business years of YKI spanned over two calendar years, going from July to June. In 1997 they were changed to match with the calendar years. Thus, the 95/96 report spans over 18 months.

interest for the study. However, in particular from the 1990s and onwards, the newsletters also contain interesting introductory pieces and sometimes other interesting parts, such as interviews with key YKI staff. This is what the analysis was focused on, and it provided input to all focus areas. The source material used is also summarised in table 3 below:

Table 3. Summary of archive material used.

Type of source	Period covered	Relating to which focus areas
Annual reports	(1970)1975-2005	Basic/applied, heterogeneity, quality control
Research programs	1975-2005	Basic/applied, heterogeneity
Research at YKI	1993-2000	Basic/applied, heterogeneity
YKI News	1981-2005	Basic/applied, heterogeneity, quality control

Some of the material from the early years of the study was published in Swedish (and in a very few cases in Norwegian – this being pages written by a Norwegian staff member for a presumed Nordic audience) rather than English. Quotes from this material used below have been translated into English by the author; it is clearly marked when this is the case.

4.3 Interviews

The interview as a choice of method is customary for a historical study in which one can expect many involved actors to still be alive. As mentioned, it is also a method that has been used successfully in earlier studies of knowledge production, research cooperation and similar topics. For the present study, 6 interviews were performed with YKI staff from various positions within the institute (see table 4 below). The focus was on informants who have been working at the institute for a long time; one person (the current president of YKI) without this experience was also included as he was considered to have potentially very valuable input to the study. The interviews were of a semi-structured character and generally relating to all three focus areas, although adjusted as needed to the position and knowledge of the informant. The focus was generally more on breadth than depth, to cover all focus areas and longer time periods without taking up too much of the informants' time. It was also desired to hear various different perspectives, not in the least to see if the view of knowledge production differs between various positions within the institute. Another important role of the interviews was to provide a counterpoint to the archival sources, to make it possible to consider differences and similarities. An interview guide was used to perform the interviews; a generic version of this guide is appendix A to this report. It was however sometimes adapted slightly to better fit with the current informant. The interviews were performed in office or library spaces at YKI. They were recorded and later transcribed for analysis. All interviews were performed in Swedish; transcription excerpts from the interviews used below have been translated into English by the author.

Table 4. Summary of the participating informants.

Name	Position at YKI	Time at YKI	Information about focus areas
Peter Alberius	President	2001-present	Basic/applied, heterogeneity, quality control (mostly focus on present conditions)
Bengt Kronberg	Former research director	1978-present	Basic/applied, heterogeneity, quality control
Kenth Johansson	Area manager Surface Modification	1984-present	Basic/applied, heterogeneity, quality control
Gilbert Carlsson	Area manager Paper Coatings	1986-1994; 2008-present	Basic/applied, heterogeneity, quality control
Irena Blute	Research engineer	1973-present	Basic/applied, heterogeneity, quality control
Annika Dahlman	Research engineer	1977-present	Basic/applied, heterogeneity, quality control

4.4 Additional remarks on the sources

To make for an easier reading of the findings, the chapter will conclude with some additional brief remarks on the sources used and their relations to the research questions. As noted, the archival sources will be used to provide both more or less straightforward facts about YKI as well as written pieces by various key actors outlining their views on the institute, its developments and its role. As with any historical source, it needs to be kept in mind that these pieces have been written in particular contexts, and so cannot be understood as straightforwardly expressing their author's opinion. Nevertheless, they contribute to the research questions by demonstrating what was seen as important for actors within YKI to project outwards and painting a by picture of the long-term developments in this respect. Over time this also gives an image of how the institute itself developed – for example in terms of its organisation, or the work it focused on.

This material is then complemented by the interviews, which contribute to the study giving access to the personal views of employees from differing positions within the institute. These views, relating to various tasks and responsibilities at YKI, are compared and contrasted with the official, outward-looking voice of the archival sources.

Two limitations of these sources must be kept in mind in reading the findings below (both will also be dealt with more extensively in chapter 6). First, the archival material does not give access to the actual decision-making within YKI, and it is wise to always keep in mind that the views put forward in for example the annual reports do not necessarily fully reflect the actual strategy of YKI. Second, the material does not deal with actual research practice but rather with discourse about this practice. For example, even if informants talk about their research, it must be remembered that the use of categories such as basic research and applied research are *their* categories rather than stemming from the author having analysed actual work.

5 FINDINGS

In this chapter, the findings of the historical study will be presented. Instead of an all-encompassing historical narrative, the format will be based around a thematic structure with each focus area being dealt with in turn. For the areas of basic and applied research and heterogeneity, a chronological narrative will first be constructed around the analysed archive materials. This narrative will then be compared and contrasted with information obtained by interviewing YKI actors. This structure is believed to be the clearest way to present the results as related to the research questions. The general structure is also used for the area of quality control, but due to limitations of the source material the narrative will be shorter and not chronological to the same extent. For the first set of research questions – those intending only to give a basic overview of the institute – more straightforward answers will be given.

This results in an account of the developments at YKI that hopefully gives the reader a clear feeling for how the institute has changed. Following this, the findings will be summarised both in an integrated way and in the form of highlighting the most interesting specific results. The summary then forms the basis for an analysis that, framed by Hessels' struggle for relevance concept, tries to obtain a deeper understanding of the changes and developments at the institute.

5.1 General information about YKI

Which and what kind of actors and institutions have been involved in the knowledge production of the institute? What were their roles? How did the institute itself develop? Has its role changed during the study period?

Generally speaking, the external actors most relevant to YKI have been state actors, industrial actors and academic actors. State involvement with YKI was for most of the study handled through the Swedish National Board for Technical development (STU) and its 1991 replacement, NUTEK. Later the state involvement became the responsibility of IRECO and then RI.SE, as discussed in chapter 2 above, and state funding has also been provided through VINNOVA, the Swedish Governmental Agency for Innovation Systems, since its establishment in 2001.

The industrial counterpart of STU and its successors has been the Foundation for Surface Chemistry Research (swe. *Stiftelsen Ytkemisk forskning, SYF*), later the Association for Surface Chemistry Research (swe. *Föreningen Ytkemisk forskning, FYF*), an organisation made up of industrial companies with an interest in YKI. Membership in this association has been open to industrial companies with an interest in the research of YKI, first only from Sweden, then extended to all of the Nordic countries in 1973 and since the 1990s without geographical restrictions. Other important actors have been various universities and university researchers in Sweden and abroad, perhaps in particular the Royal Institute of Technology in Stockholm with which YKI is co-located, and the European Union for research funding (since the 1990s).

STU/NUTEK and FYF funded research according to the model outlined in chapter 2, with a base funding programme that was re-negotiated every three years, along with possibilities to apply for further contracts and grants. Throughout the study period, the relative level of the base funding generally decreased, making it more and more necessary to make applications for money from these and other sources. Furthermore, the portion of the base funding provided by the state decreased in relation the portion provided by industry.

FYF and STU/NUTEK also exerted influence on the work within YKI. The YKI board was appointed by both organisations (each got to pick a fixed number of people). Also, the industry

had influence over the research sections within YKI, effectively taking part in the formation of research programs (though the extent to which the industry actively influenced this formation varied over the study period). Furthermore, there was the so-called industrial committee, which provided feedback and an industrial perspective on the research performed at YKI. Unlike the industrial representatives to the YKI sections, this committee had a more advisory role and was formally not able to actively steer YKI research (interview Bengt Kronberg). Otherwise, the general direction of the institute was controlled by YKI management, with the director of the institute as the primary actor. The different directors, and their time in the position, are listed in table 5 below:

Table 5. Directors of YKI, 1975-2005.

Name	Time as director
Stig Friberg	Start of study - 1977
Per Stenius	1977-1991
Krister Holmberg	1991-1998
Martin Malmsten	1998-2003
Bruce Lyne	2003 - end of study

This general organisation as described above persisted through most of the study period, until YKI was turned into a limited liability company in 2001, with a changed ownership structure and funding model.

The development of the institute can be succinctly summed up as going from a small Swedish laboratory working in a new and relatively unexplored field to an internationally oriented research organisation with good reputation. It has grown quite considerably, and it has expanded its orientation. As one measure of the growth of the institute, figure 1 below shows the number of employees of YKI during most the study period:

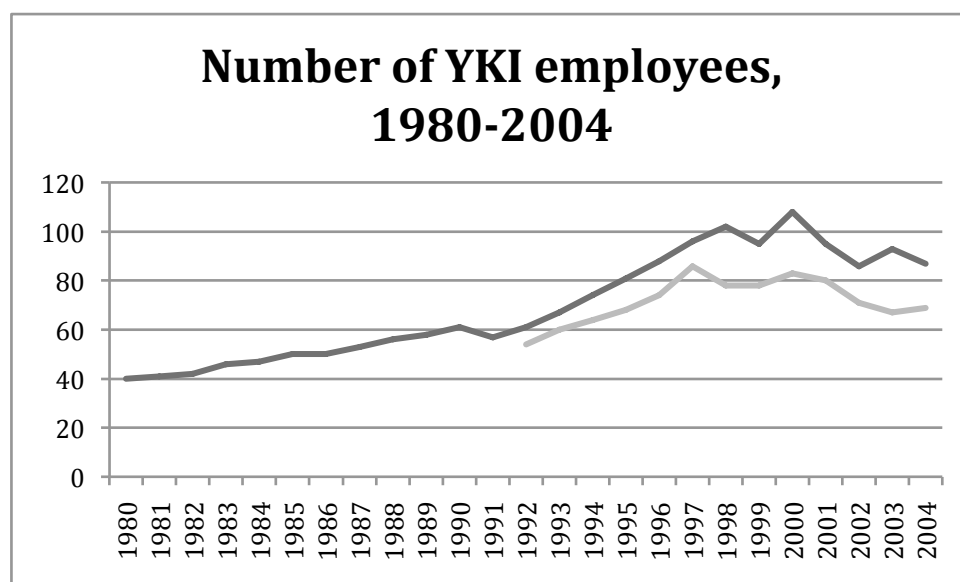


Figure 1. Number of YKI employees, 1980-2004. Also includes full-time equivalents, 1992-2004. Source: YKI annual reports.

As can be seen, with respect to number of employees YKI grew almost continuously up until the end of the 1990s, after which there has been a slight downturn coinciding with a significant loss of public funding (see chapter 2). The lower line, indicating full-time equivalents from the start

of such reporting in 1992, shows that the peak in terms of actual work hours in fact took place slightly earlier.

Throughout, the general role of the institute has remained the same – to support Swedish industry by performing surface and colloidal chemistry research. The details of this development, and the various ways the role of YKI has been expressed, will be detailed in the findings relating to the main focus areas below.

5.2 Basic research and applied research at YKI

How can it, in the output of YKI, be distinguished between work that is basic and applied? If such a distinction does make sense, which trends of increasing or decreasing basic or applied research performed by the institute can be discerned for the study period? How can these trends be explained? Also, how have the actors and researchers at YKI themselves used these categories; what is their image of YKI-performed research?

To begin with, it is clear that the distinction between basic and applied has played a central role at YKI throughout the study period. The terms are used in almost every YKI publication reviewed, often accompanied by long discussions of their importance and their role in the workings of YKI. Also, a distinction between basic and applied is upheld throughout – the categories are taken to refer to two distinct types of research (though it is sometimes acknowledged that the distinction can be less than absolute), although the way the relationship between the two, and their relative importance, is understood has changed, with basic research gradually becoming less important. In the interviews, a similar picture emerges, with the main point of divergence being the timing of the changes.

5.2.1 Archival findings, basic/applied

At the start of the study period in 1975 and during the following five years, the two categories of basic and applied research were organisationally completely separate. The basic research was performed in its own organisational form, while the applied research and the research directly commissioned by industry were organised into industrially oriented research sections. This organisation is described as follows by the then-director of the institute Stig Friberg (this is before the start of the study period, but the structure would remain the same for some time):

During the year the activities of the institute have brought us nearer to the definitive organization of the institute. In this organization the basic research and the educational activities of the institute are collected into a central unit, while the applied projects and the contract research are performed in sections involved with separate branches of industry or industrial processes. (YKI annual report 73/74, p. 1)

The separation between basic and applied can also be seen in the organisational chart below (basic science is 'Grundläggande forskning'; 'Tillämpade projekt' means applied projects:

Organisationsplan

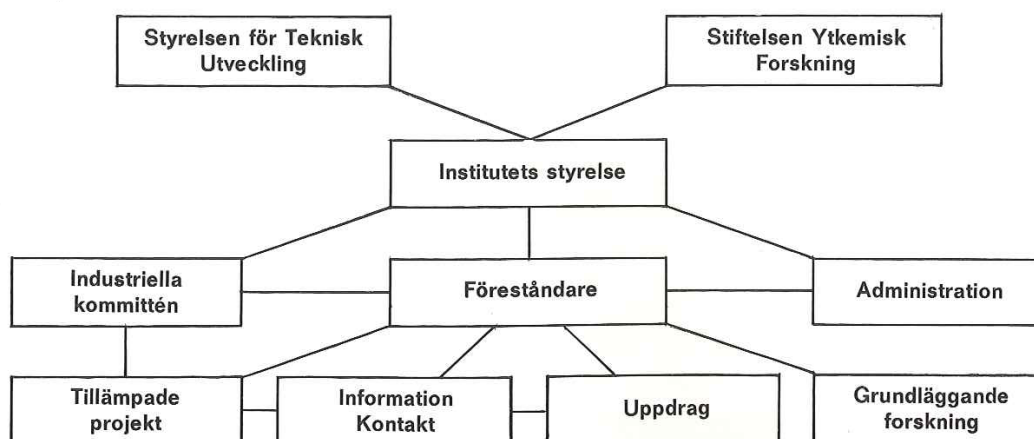


Figure 2. YKI organisation 1973/74. Source: YKI annual report 73/74.

Basic research was considered important for the institute at this stage, one of its main goals being the performance of basic research (YKI annual report, 77/78). The amount of basic research work was small in relation to the applied and commissioned work, but both the institute and the foundation were interested in increasing the amount – the utility of this seemed rather uncontroversial, as little argumentation was presented (YKI annual report, 76/77). The basic research was – unsurprisingly enough, considering YKI's role as an industrial research institute – generally motivated by instrumental reasoning. One recurring argument related to the need of building up and maintaining the scientific competence of the institute and its staff (e.g. YKI programme budget 79/80, 3:1). Another point made was that basic research at YKI is important because there is no such research at Swedish universities. YKI was thus the only Swedish actor producing basic knowledge in the field of surface chemistry at this stage (YKI annual report, 76/77). This in turn relates to the most common argument used, namely that basic research is necessary to establish a fundamental knowledge base that can be used for work on applied problems:

The purpose of the institute is to form an efficient research group with a fundamental knowledge of recent advances in colloid and interface science which could be utilized for applied research on industrially oriented problems as well as for direct contract research. To maintain this knowledge, it is essential that the institute conducts independent fundamental research in areas of surface science which are of high relevance to industrial applications of interest to the institute's members. (YKI annual report 79/80, p. 6)

Some form of a linear model is discernible in the quote above, with its reference to how fundamental knowledge could be utilised for applied research. It also seems clear that basic, or fundamental, research was considered to be of an oriented character: basic in the sense of having no particular application as a goal, but still directed towards areas interesting for industrial applications. But the matter is somewhat complicated by considering other materials: in the programme budget for 79/80 two forms of research are explicitly mentioned, basic research and directed basic research. These terms are explained as referring to the creation of new knowledge and the creation of a foundation for applications. Even within the institute and during the same year, the terminology was thus somewhat muddled.

Considering this, it is perhaps not strange that there also were some acknowledgements, and some implicit indications, that it could be hard to distinguish between basic and applied, and that the organisational division not always reflected practice. For example, in the 76/77 yearly report, the acting director of the institute, Inga Wilton, claimed that the basic research, applied research and commissioned research had been highly 'integrated' during the year. During the same year, it was reported that some basic research had been performed within the industrial sections, due to the leave of absence of the regular director, and three years later it was mentioned with appreciation in another yearly report that also the commissioned research can contain basic studies if the project is large enough. Nonetheless, according to the organisational plan of the institute, basic research remained separate but now linked to the applied research. In the plan, basic research is 'Grundläggande forskning', still a separate unit but now linked to the eight sections in which contract research ('Uppdrag') and applied research ('Tillämpad forskning') were performed:

Figure 3. YKI organisation 1978/79. Source: YKI annual report 78/79.

Very frequently during the last years we have stated that a basic research which enables to keep the institute in touch with the most recent developments in colloid and surface science is essential to the institute's function as an industrially oriented research organization. In comparison with most other similary [sic] organized institutes in Sweden, fundamental research at YKI has been rather strongly emphasized. It is with great satisfaction that we note that the skills and knowledge developed through this approach now is beginning to pay off in a rapidly increasing volume of contracts and projects that have been directly initiated by industry. So far, we have seen no signs of abatement in the number of ideas and initiatives resulting from our basic research program. (YKI annual report 81/82, p. 6)

Again, the terminology was more complex in the research programmes. In the 1980-1983 framework programme, YKI's objective is described as directed basic research and applied research, but in a bit later in the same document, simply basic research is used and motivated as above, though here it also stated in a very clear manner that autonomous and creative research work is the sole way in which both the required knowledge and the required skills to perform applied research can be obtained (YKI framework programme, 1980.07.01-1983.06.30). The terminology muddle remained during the following years: the terms basic research and directed basic research were used in a manner that does not appear systematic. It was however pointed out that the term 'directed basic research' refers to work that is directed largely by the institute itself (YKI programme budget, 82/83).

Two years later, in his introduction to the 83/84 annual report, director Per Stenius made a very interesting statement that somewhat clarifies his conception of the relationship between basic science, applied science and industrial development. He used the term 'three-stage rocket' to characterise this development, the three stages being basic research, general applied research and direct and confidential development work, and argued that the ideal proportions between the three would be a 3:2:1 ratio. This is again thus a kind of linear model, stated rather clearly and explicitly: basic science leads to applied science which then leads to development.

In the same annual report, the director also warned about an ongoing parliamentary discussion about the public funding of research, potentially threatening the above-stated model and in particular how it is paid for. In relation to this, it is quite an interesting observation that in the rest of this report, the focus is more than ever before on applications of YKI research. Even the pages dedicated to basic research are less a presentation of ongoing research project and more a summary of the general state of the field. Furthermore, a page not present in earlier annual reports has been added, listing tangible examples of industrial applications of surface chemistry. This indicates that the institute found it important to point out the industrial utility of its research in a more explicit way than before. One should naturally avoid drawing far-reaching conclusions from the structure of a single annual report, but it is interesting that this coincides with the concern over possible funding changes, thus illustrating the complexity of the basic-applied concepts as used by YKI and the way in which they can be used to get a point across with policy makers and other stakeholders.

As should be clear from the above, basic research and applied research were important concepts at the institute during the first ten years of the study. They are not only clearly distinguishable in the various text pieces of the annual reports and research programs, but they were also kept organisationally separate. However, there are indications that this clear separation was not always achieved in practice: on occasion it was acknowledged that the two categories could be

integrated, and the terminology was occasionally a little bit muddled (even if one should not draw too far-reaching conclusions from the latter: in the context of YKI, basic research and directed basic research are probably in almost every case best understood as synonyms, and the use of the different terms might well reflect individual writer's preferences). No clear trends in their use are discernable at this stage, but the final example used above indicates that YKI was starting to feel the political pressure from the policy reorientation vis-à-vis the institutes that started in 1975 and possibly intensified after the FOSAM-committee report in 1980.

The pressure was however temporarily relieved when, in 1986, it turned out that the institute, in spite of the earlier worries, was allocated more resources both from public and private interests (though proportionally more from the industrial sponsors). In relation to this, the director pointed out that it is critically important for an institute like YKI to be able to freely perform basic research, and that this freedom can only be guaranteed through government support (YKI annual report, 85/86). This was not a break with earlier positions, but it again seems possible to discern how the institute in its annual reports employs the terms basic and applied research differently depending on current signals from policy makers – when funding is threatened, applied research and tangible applications are presented (to perhaps help secure funding), and when the funding situation appears secure the importance of basic research is emphasised (to perhaps 'defend' the role of basic research at the institute). At the same time, a change in the organisation the institute's research means that the basic research now is presented alongside applied research below the industrially-oriented research sections, rather than as an independent unit:



Figure 4. YKI organisation 1985/86. Source: YKI annual report 85/86.

In the same report, professor Ingvar Lindqvist from the University of Agricultural Sciences argues that the work of YKI is distinguished by its 'appropriate long-termness', which is to say that the institute has an appropriate distance to industrial needs. He also discusses the then-prevalent idea of the universities as 'research institutes of society' (see also chapter 2), an idea that de-emphasised the role of the industrial research institutes, and claims that YKI, on account of its good connections to the Royal Institute of Technology and other institutions of higher education and academic research, still can form a part of this future vision.

Continuing into the late 1980s, there are further signs of YKI coming under increased pressure from the outside again, with an increasing dependence on industrial sources of funding. Though the institute generally had been able to secure increased funding from year to year, the proportion of money coming from industry had been increasing as public funds increasingly were redirected to the university sector. In the 1986/1987 annual report, it is noted on two occasions that it is both getting harder to access public money, and that the industry might be unwilling to pay more for fundamental research without their contributions being matched by the government. Following this, the director's page in the 1987/1988 annual report was largely devoted to a defence of YKI and to the industrial research institute as an organisational form – that the institutes are important in what he called the 'constant struggle' to develop science and technology. He argued that they have an important role to play in a research system where connections between basic research and industrial development are seen as increasingly important. He also argued that collective research exists not in the least because the industrial actors themselves consider it important with industrially-oriented research organisations that have the capability to perform basic, long-term research. In the same article, the importance of public money to guarantee free basic research was also emphasised, along with the necessity of stable financial arrangements. The following quote is rather characteristic:

The objective of the institute is not only to do research but to assure that the research is of relevance to industry, to transfer the results into industry and to maintain an organization that is easily available and able to efficiently attack the specific both very short-term and long range problems in product and process development at short notice.

The balance between developing the quality of the institutes through long-range research and their skill in short-range problem solving is a delicate one. Dramatic changes in the ratio between governmental and industrial support are bound to disturb this balance seriously and will be disruptive to the basic working principle of the institutes. (YKI annual report 87/88, p. 1)

Basic and applied research were thus presented as pieces of a puzzle that need to fit together – not only are both needed, but a finely-tuned balance between the two are necessary. If the financial foundations of the institute are insecure, this balance will be hard to uphold. The following year, it was made even clearer that from YKI's point of view, they are navigating through a complex situation with new demands to which the institute must adjust in a manner that demonstrates its value not only to the industrial actors but also to policy makers:

The outcome of the debate and the ability to adjust to new demands is of very great importance to the cooperative research institutes. It is our task to ensure that the essential role played by these well established institutes in advanced technological research as well as their organizational flexibility and their resources in terms of scientific instrumentation are truly appreciated not only by industry but also at all levels in the decision-making governmental hierarchies. (YKI annual report 88/89, p. 1)

Interestingly, in the same report it is stated clearly that a basic criterion for the choice of research topics is that the research must be directly related to industrial applications. Put this way, the statement is quite radical compared to the earlier pleas for autonomous basic research and is another sign that applied research and direct industrial relevance are resources drawn on

when the institute is perceived as being under external pressure from policy makers. Furthermore, also in the same report the chairman of the board made a remark to the effect that basic and applied science more and more are overlapping; another step away from the idea of free basic science as a central and independent part of the institute.

With the political situation in Europe changing radically, the general theme of 'protecting' the institute continued in 1990, with another argument by the director about the relative sensitivity of research environments and the danger that is posed to them by rapidly shifting and short-sighted demands (YKI annual report, 1989/90). This argument, which was continued also in 1991, is closely tied to a classical 'policy for science'-view, essentially saying that scientists should get stable long-term funding while as far as possible being shielded from disturbing outside steering. Throughout, basic research remained a central topic, now motivated exclusively by its necessity for later applications. The reasoning was somewhat more sophisticated than simple linear model thinking however: basic research does not only enable YKI to do what the industry wants, but also to know in advance what the industry needs.

Generally speaking, the 85-90 period marks a transition: by the end of this period, it had become impossible for the institute to defend the performance of free, autonomous basic research. From this point on, basic research was always closely associated with technical relevance and industrial benefits. It does not necessarily signify a decrease in the amount of basic research performed, but it does signal a general decrease in support for research not directly aligned with industrial needs. Another sign of this is how basic research is moved close to applied research in the 1986 organisational chart. And while the period was not marked by any significant external events, this can still be seen as adjustments to a negative political climate in which the institutes, if mentioned at all, were associated mostly with applied research, and in which more and more money was given on an application basis instead of base funding with few strings attached.

In the 1991/1992 annual report, basic research was completely removed from the organisational plan as a separate entity. This should not be taken to imply that there no longer was basic research at YKI – that was still performed within the research sections and in the Surface Forces Group, a recently created collaboration (enabling for example the sharing of research staff and research tools) with the Royal Institute of Technology – but it says something about how YKI was adjusting and how it wanted to present itself (compare with the situation in 1975, for instance). In particular, it can be seen as indicative of wanting to present basic and applied research as having a more close relationship.

Organization 1991/92

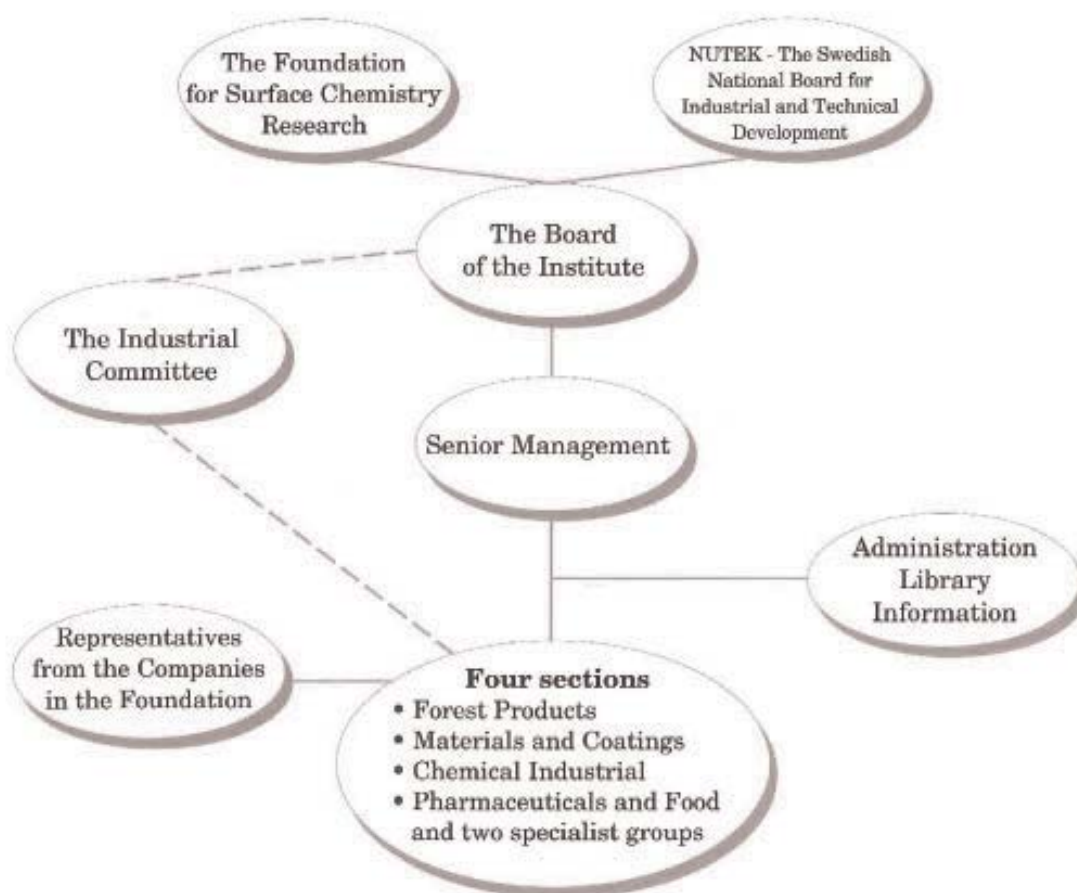


Figure 5. YKI organisation 1991/92. Source: YKI annual report 91/92.

Note also these quotes from the following year: "A strong industrial interest does not necessarily mean more emphasis on short-term research. YKI has traditionally been oriented towards long-term, strategic research and it is our ambition to maintain it that way." (YKI annual report 1992/1993, p. 1) and: "We believe that [increasing industrial competitiveness] can best be achieved by carrying out long-term research projects which are relatively basic in nature but are of definite relevance to industrial problems." (YKI annual report 1992/1993, p. 1). This rhetoric was not new (though the use of the term 'relatively basic' was), but in combination with the removal of basic research from the organisational plan the dichotomy of basic and applied comes off as less absolute. Similarly, basic research gradually lost its own pages in the annual report, eventually being completely subsumed under the pages of the industrial sections and the Surface Forces Group (the 1990/1991 annual report is the last to have a separate part called 'basic research'). Around this time it was also made clear that most of the long-term basic research is now performed by PhD students.

Over the next years, a certain stability was achieved. Basic research was generally mentioned in direct connection with applied research, and it was emphasised that the more basic activities must cohere with industrial interest: "However, it is also very important that these more basic activities are consistent with industrial interest. Our aim is to run industry-sponsored and government-sponsored projects side by side in all research areas." (YKI annual report

1994/1995, p. 1) In this context, it was still always asserted that the basic research is important for the institute, while at the same time, it was given less space than ever before in the annual reports. The following example from the research program is also illustrative:

Research at YKI has a strong emphasis on technically relevant problems. In principle, all activities have some industrial connection and during recent years this ambition has been increasingly pronounced.

However, strong industrial influence does not necessarily place emphasis on short-term research. Traditionally, YKI has been oriented towards long-term, strategic research and it is YKI's ambition to continue as such. [...] Most research at YKI aim towards clarifying basic surface chemistry phenomena associated with applied problems." (Research at YKI, 94/95, p. 1)

Continuing into the late 1990s, a trend of further decreasing importance for basic research is clearly discernible. In the 95/96 annual report, the director emphasised that it is important for YKI to maintain its connections with basic surface chemistry research in academia. This can be seen as signalling a reduced importance of in-house basic research – although he also mentioned that YKI has a tradition of such research, it was not motivated or defended to the extent that it earlier used to be.

In the 1997 annual report, the director – now Krister Holmberg – identifies a trend towards large, international applied research projects. While he does mention the existence of network projects for basic research, in the discussion of financial issues it is clear that the industrial research has stable funding, while the funding for basic research is only 'reasonably' stable. Basic research can thus be considered to be much more conditional than before. It is also notable that in the presentation of the various sections in this same annual report, the Surface Forces Group, where a lot of the basic research was performed, is considered to be scientifically oriented, in contrast to the industrially oriented sections. It is possible to get the impression that the basic and academically oriented research was now somewhat 'outside' the main organisation, rather than being a central and integrated part.

Throughout the 1990s, basic research thus kept losing ground in the YKI publications: already by 1992 it had lost its own pages in the annual report and had been removed from the organisational charts. While this indicates a closer association with applied research, it should be clear from the above that basic research remained a category used to describe certain research and so remained distinct from work described as applied. On the political level, the period was characterised by a relative calm and by a continually hesitant or negative policy attitude. While the institute sector in 1991 was the subject of a government inquiry that was mostly positive, its proposals were not taken up, and while the Swedish research policy was reformed through the wage earner fund foundations, this did not have any direct impact on the institutes. The decreased importance of basic research, and its closer association with technically relevant problems, can thus be seen as a way to work more closely with industry and as a continuing adjustment to the political climate.

A further notable shift can be seen in descriptions of YKI research from 1998 and 1999. Here, neither the term 'basic research' nor any of its synonyms were used. Instead, it was emphasised that all research at YKI must have a direct connection to technically relevant problems. This stance was directly motivated by the current funding situation, as in the following quote:

For a research institute such as YKI, a dominant part of funding either comes directly from industry or is conditionally based on industrial support. For this reason, but also in order to fulfil our objective of increasing the competitiveness of our member companies through applied surface chemistry, it is crucial that all research at YKI strongly emphasises technically relevant problems – originating from ideas concerning industrial products and processes. (Research at YKI, 1999, p. 1)

In the new millennium, a serious matter for YKI was yet another government review of the future of the innovation system in general, and the institute sector in particular. Though a long-term interest in the institutes was eventually announced, YKI leadership considered this a time of transition, with the director Bruce Lyne announcing in 2003 that YKI was transitioning from the traditional public funding to a: "greater emphasis on work for industrial clients and being appropriately paid for the value delivered." (YKI annual report, 2003, p. 1) The year after, similar views are expressed: "Operational income continues to transition from public funding to industrial income and the challenge is to expand the base of projects performed for industry to maintain balance as national public funding sources decrease support for the institute sector." (YKI annual report, 2004, p. 4) The term 'basic research' is not used at all. On the other hand, in an interview in YKI News in late 2002, a new section manager at YKI, Andrew Fogden, made the following quite traditional statement: "My belief, and indeed that expressed most often by industry, is that relevant basic research is the cornerstone to attracting and keeping member companies." (YKI News 3/2002, p. 10). Up until the end, the relationship between basic and applied within YKI seems to have remained complex.

5.2.2 Interview findings, basic/applied

Even if the interviewees generally acknowledged that it sometimes can be hard to make a sharp distinction, the view of basic and applied research as meaningfully distinct categories recurred in most of the interviews. For example, former research director Bengt Kronberg considered basic research to be curiosity-driven research leading to knowledge of general principles, while applied research is research relating to particular technical questions. He gives the following example of basic research from his own work at YKI:

For example, I was asked by industry, what surfactant should I use for this. Then I performed basic research, and that was studying – I'm talking some chemistry now *laughter* – studying adsorption of surface active substances on solid surfaces. How they attach to surfaces and so on, to be able to answer the question from a general point of view. And then from this general knowledge it's possible to draw the conclusion that you should use this and this, and maybe mix in this and this. So it is these laws of nature that one searches for. (Interview Bengt Kronberg)

This is kind of basic research in surface chemistry that leads to general knowledge about the effects of surfactants (surfactants are substances that modifies surface tension) on surfaces, though it is also of an oriented character seeing as it is performed within an area outlined as interesting by the industry. The vast majority of what is called basic research of YKI is and was of this kind¹², something also supported by Gilbert Carlsson who saw research at YKI in the 80's

¹² Kronberg however also mentioned a curious experiment, in which foam was taken on an airplane flying parabolic trajectories to test the effects of a zero-G environment on it. This peculiar investigation was

and early 90's as being rather free, but still related to specific areas of interest. Only one of the informants, Kenth Carlsson, was more ambivalent about distinguishing basic and applied, arguing that the border between the two can be fuzzy and that many projects provide room for both more basic and more applied work. Even so, he saw it as possible to make a distinction: basic research then being more about producing new knowledge, and applied research about applying knowledge to e.g. new domains. Furthermore, it should be noted here that like Kronberg did in the excerpt above, the informants generally were able to link up the terms basic and applied to their own work, further supporting that the categories are meaningful to them in relation to what they do at YKI, and not just phrases and definitions to be repeated.

It is possible to discern a linear model in the excerpt from the Kronberg interview above, with more basic research leading to general knowledge that later can be applied. A similar view was expressed by Carlsson, who sometimes observed how free research would form the basis for later applied industrial projects, and by Irena Blute who in her comments on the nature of basic research came quite close to an explicit formulation of a linear model:

IB: At the same time, it is, basic research also has its goal, when you have the base it becomes applied, then you can see how it could be applied.

KB: How would you define basic research then?

IB: Basic research, creation of a base for applied research. That is my interpretation. (Interview Irena Blute)

But Kronberg also pointed out that it was common for the process to be reversed, with applied research giving rise to the need for general knowledge. When talking about his work in founding the polymer section of YKI early during his time at the institute, he directly mentioned the idea of a linear model, stating:

Usually you have this line, going from basic research to applied, but here it was the other way around, the question goes from applied to basic where you generate a knowledge base to be able to, yes, answer those questions. To know what is important, so to speak. (Interview Bengt Kronberg)

Blute also mentioned this reversal; that applied industrial research could lead to demands for more fundamental work: "Because maybe they had reached certain conclusions, certain results within the industry, and they wanted to get in deep, to see what was behind it." (Interview Irena Blute) This resonates very well with the idea that an industrial research institute could step in to fulfil basic research needs for companies, as was outlined in chapter 3 above. One might perhaps consider it a linear model, but with feedback loops included. This would illustrate an important characteristic of YKI and industrial research institutes in general: given their work and organisational structure, they have direct access to industrial feedback on their research. It would be rather strange to argue for a full-blown unidirectional linear model in this context, where industrial input always has helped shape the research agenda.

In the section on the archive material above, a clear trend was the decreasing importance of basic research. This generally fits with what was expressed in the interviews: the only informant who did not readily see a decrease in the amount and the emphasis on basic research was Kenth

completely curiosity-driven yet ended up contributing to the solution of an industrial problem several years later. But airplanes or no airplanes – such pure basic work was very uncommon at YKI.

Carlsson, but he also stated that the view on this likely would be influenced by where at YKI someone had been working. Otherwise, informants agreed with the trend of decreasing importance for basic work. A clear example of this view is the following statement by Annika Dahlman:

Yes, it has changed a lot towards more applied [...] It has been going a little back and forth, but in principle towards less [basic research] all the time. And it is a question of funding, and yes, maybe also about the orientation [of the institute].
(Interview Annika Dahlman)

While agreeing with the general trend over the study period as a whole, other informants had a different view on the timing of the process. Both Bengt Kronberg and Peter Alberius (who very likely had this different perspective based on their better access to the 'big picture') talked about how basic research was first established at YKI by director Per Stenius, who led the institute from 1977 to 1991. According to Kronberg, Stenius built up a platform for basic research and remained committed to such research throughout his time at the institute. This is not apparent from the archive materials, in which a decreased commitment to basic research can be discerned from around the mid-1980s. Furthermore, and even more in conflict with the archive material, both Alberius and Kronberg states that a large amount of basic research had been performed throughout the 1990's, with Alberius arguing that the level of basic, long-term research remained very high even at the start of the new millennium:

It says something about the balance between applied, industrially-oriented research, 75% [of YKI research] and around 25% a bit more long-term [research]. And that is about the balance that we need to have. If you consider the situation ten years ago there was a completely different balance at YKI. Then we had more than half in long-term research funding. We had over 20 doctoral students at YKI at the start of the millennium. (Interview Peter Alberius)

Here, Alberius apparently agrees with the view expressed by Stenius in 1988 that a finely tuned balance between basic (or long-term) and applied research is needed, even if the two directors clearly are not in agreement about the most suitable ratio. But more interesting here however is the clear statement that more than half of YKI's research was of a long-term nature (long-term might not always necessarily mean basic, but when tied to PhD students, as in this context, it usually does) as late as 2000, clearly conflicting with gradually decreasing emphasis on basic research that is discernable in the archival material from the mid-to-late 1980s? Given Alberius' position, it is inconceivable that he would be mistaken about this issue, in particular as it was further supported by Kronberg who mentioned that after Stenius' had constructed a platform for basic research, he was succeeded as director by Krister Holmberg who through his extensive connections with research funders was able to secure a lot of money for this basic research (Holmberg led YKI until 1998). How can the discrepancy be understood?

One interpretation would be that the role of basic research at YKI was intentionally downplayed in the annual reports as part of a struggle for relevance, but that this did not reflect the actual work at the institute. This is fully in line with Jane Calvert's (2006) earlier research about the employment of the concepts of basic and applied to achieve particular (political) objectives, without it necessarily reflecting actual research activity. This struggle for relevance would have been triggered and reinforced by the increasingly insecure funding situation. Gilbert Carlsson, who was a PhD student and researcher at YKI in the late 1980's and early 1990s, mentioned that already when he was new at YKI it was becoming apparent that funding, in particular base

funding for free research, was decreasing and would continue to decrease. This fits well with the general attitude expressed in the archive material as well.

But the orientation away from basic research can be explained in a different way as well. Both Alberius and Carlsson mentioned the fact that general knowledge level within industry has increased significantly since the start of the study period, thus also changing the role of the institute, as in the following excerpt:

The industry is much, much better educated today. There exists incredibly advanced technical development in especially larger companies, which really is incredibly close to basic research. So it must be remembered that the role for the industrial [research] institutes also changes as the level of education in industry increases. (Interview Peter Alberius)

In other words, it is not self-evident that the institute oriented itself more towards applied projects because applied research always is easier to fund. Rather, the decreased emphasis on basic research might have coincided with a decreased interest in such research from the industrial sponsors. On the other hand, when Carlsson expressed the view that research has become more applied today, focusing on providing knowledge *and* practical results rather than just knowledge, he motivated it with a decrease of funding for free research. Presumably these explanations are not independent of each other. At any rate, if YKI performed large amounts of basic research well into the 1990s, then the second explanation can only be valid for the last five or ten years of the study.

For the very last part of the study period, there is agreement between what can be seen in the archive materials and the interviewees' opinions. There seems to be little doubt that YKI during the 21st century, and perhaps in particular during the years after this study ends, has committed itself to mainly performing applied research and to transfer of innovations to industry. The institute retains its research competence, but it is no longer seen as necessary to be able to develop competence in entirely new areas of research (interview Peter Alberius; Gilbert Carlsson). Director Peter Alberius was quite unambiguous about this matter, stating that: "YKI shall not perform basic research, that is not our mission" (Interview Peter Alberius).

5.2.3 Summary of findings, basic/applied

To briefly summarise the archival part of the findings, it can first be said that at least on the surface, it is quite easy to distinguish between basic and applied research within YKI. Indeed, if only one thing was to be said about this material, it would have to be something relating to the very strong importance that the institute seems to attribute to these terms as referring to two separate categories of research throughout. If the material is read closely, it is however less obvious what is what. The term 'directed basic research' is sometimes used alongside basic research, even if they for the most part seem to mean the same thing. Furthermore, it is sometimes emphasised that basic and applied can be hard to distinguish from each other. A second finding is thus that the clear separation between that the institute insisted on, in particular during the first half of the study period (which is also apparent from the early organisational charts), might not always be clearly reflected in practice. Finally it can be said that over the period as a whole, a clear trend of decreasing importance of basic research as a category can be discerned. From the start of the study period until roughly the mid-1980s, the institute in its annual reports and research programs generally remained committed to the importance of autonomous (though not completely undirected) basic research and to a kind of linear model. In the late 1980s and in particular the early 1990s, basic research remains important but is more and more directly associated with applied research and particular industrial problems. In the late 1990s and into the new millennium, basic research, though still

present (and sometimes hailed as very important) at YKI, becomes more of a side phenomena and is mentioned less and less, the prevailing idea being that all research needs to be of direct relevance for technical problems.

Considering the interviews, the picture is in many ways similar. The interviewees generally agreed with a distinction between basic and applied and could also link it to their own work. With one exception they perhaps even saw this distinction as a bit more clear-cut than what was discernable in the archive materials. This finding is very interesting, and it should be emphasised that it is rather strongly supported, given that the informants came from different parts of the organisation and had very different roles, going from research engineers to high-level management. The informants considered almost all basic research performed at YKI to be of an directed character. They also mostly agreed about the general trend of a lessened importance for basic research at YKI during the study period, but the timing of this shift diverged notably from the archive materials. First, and less significant, it was claimed that basic research really only became important at YKI when Per Stenius became director in 1977. This is not seen in the archive materials, but it could be explained by the fact that the institute was still finding its form and role at that time. Second, and more interestingly, according to at least some of the interviewed actors basic research remained very important at YKI into the late 1990s, a time when the emphasis on such research had decreased notably in e.g. the annual reports. The interviews and archive material do come together again for the last five years of the study: the interviewed actors generally agreed that YKI in the new millennium has committed itself to a focus on performing applied research. The more basic activities have not disappeared from YKI completely, but they are seen as less important than before.

5.3 Heterogeneity of YKI knowledge production

How has the knowledge production of YKI changed with respect to heterogeneity (in the sense of involving more or less different partners) during the period of study? How have the traditional relationship with universities and with the industry, and the institute's general role in the innovation system, changed? How do the actors and researchers within YKI consider the role of the institute?

Just like the basic-applied distinction, external relations appear (perhaps not very surprising) to have been very important to the institute throughout the study period. They are discussed at length in the reviewed archive material, usually in a context of establishing YKI's role vis-à-vis its partners and sponsors.

Throughout the study period, YKI knowledge production has generally become more heterogeneous in the sense of involving an increased number of different partners (it might be argued that an increase in the number of industrial partners does not necessarily imply increased heterogeneity of the knowledge production, but in this case, new clients would mean that YKI had to work with new corporate cultures and, at least to some extent, with new problems). As a first example, figure 5 below details the number of member companies in SYF/FYF:

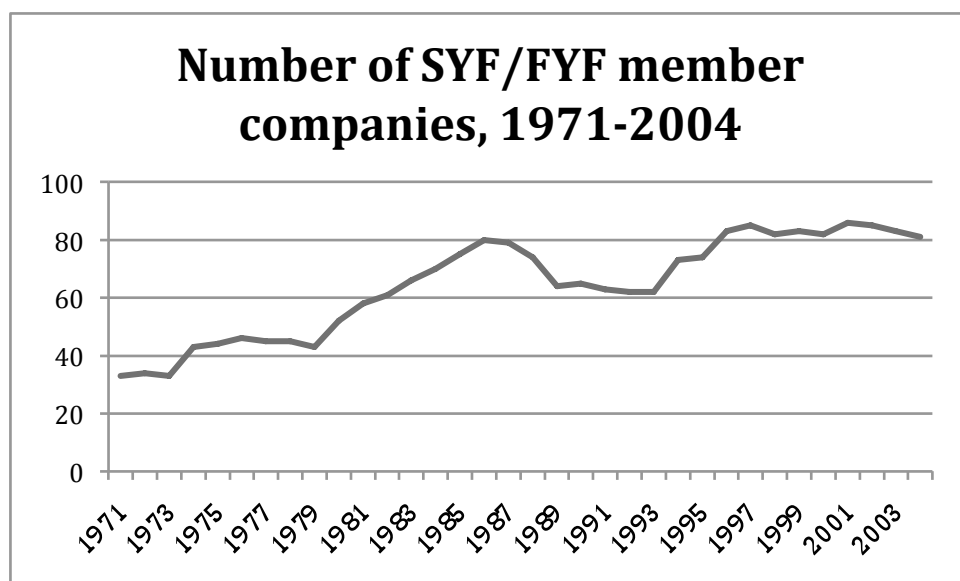


Figure 6. Number of SYF/FYF member companies, 1971-2004. Source: YKI annual reports.

For the first fifteen years, there was a clear trend of growth. Although the number then has not increased significantly after the mid-1980s, there has still been some diversification after the early 1990s, as new companies from outside the Nordic countries started to join. In 2002 non-Swedish companies amounted to about 40% of the members, of which slightly less than half come from outside the Nordic countries, as indicated in figure 7 below:

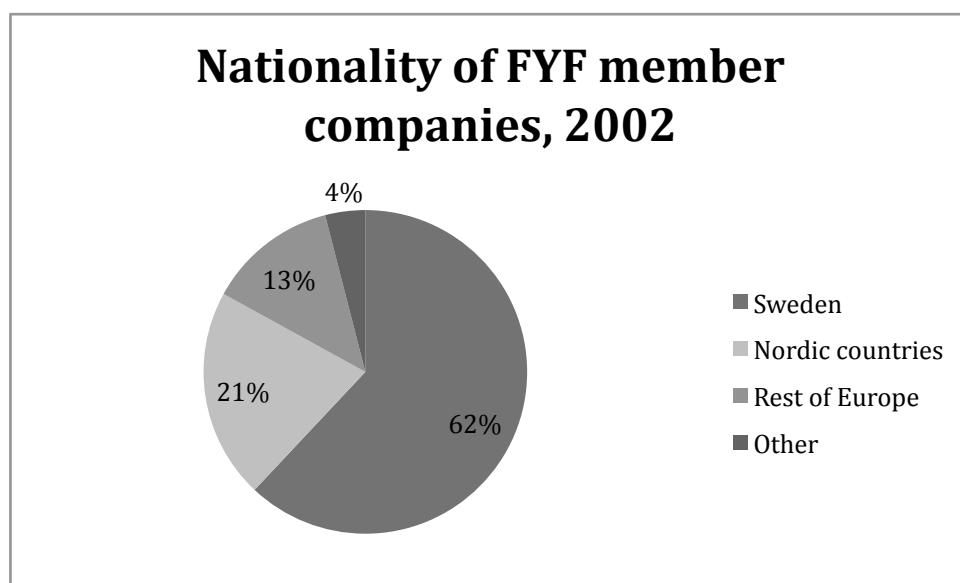


Figure 7. Nationality of FYF member companies, 2002. Source: YKI annual report, 2002.

At the same time, a general pattern of a clear bi-directional orientation towards academy and industry was present during the whole period – implying that the most important external contacts were industrial companies and universities, and thus that the increase in heterogeneity did not particularly extend to include non-traditional actors – with an increasing emphasis on industry over the course of the period. In addition to the increased emphasis on the industrial contacts, what also appears to have changed is YKI's conceptualisation of its own role in the research system. As with the first focus area, the interviews provide a rather similar picture, with the timing of the identified changes – in particular the increasing emphasis on the industrial connections – diverging somewhat.

5.3.1 Archival findings, heterogeneity

From the beginning to the end of the study period, it was emphasised in the archive material that for YKI as an industrial research institute, it is of the utmost importance to maintain good relations with the industrial actors that help fund YKI research, and with companies who are potential sponsors. The most important part of this is naturally to perform research that companies see as relevant and useful, as clearly stated in the following quote from early in the study period:

The most important part of YKI's external relations is directed towards the industrial companies already members of the Association for Surface Chemistry Research as well as towards potentially new members. The Institute's research program is formed in close co-operation with these industries in order to give new fundamental inputs to their own process- or product development in which the Institute also often co-operates on a contract basis. (YKI annual report 77/78, p. 6)

At that time, most of this research did not constitute joint production of knowledge with industry, but was rather performed by YKI alone, but with industrial actors helping to shape the general research program. The latter part of the above quote might occasionally have constituted joint production of knowledge, but was most often a form of consultancy in which YKI was given a particular development problem to work on by itself – even if this naturally also included some more or less close cooperation.

In another quote from the same report, the nature of the second important external relationship – that with academia – is also elaborated. After restating that the industrial connections are the most important, it is made clear that an important task for YKI is to make academic knowledge available to industry:

A close contact with the industry is the basis for the Institute's existence. Of importance in this relation is also the responsibility of the Institute for the development and transfer of new knowledge from university to industry. This has been one of the major concerns during the year, and co-operative projects have been initiated with a number of external resources. (YKI annual report 77/78, p. 6)

The 'external resources' refers here to academic connections of YKI. Unlike the relations to industry, these relations were marked by a high degree of joint research work, a pattern visible throughout the study period. YKI researchers would collaborate with researchers in academia, YKI would often receive visits from important researchers, and so on. The knowledge thus produced and obtained would then be transferred to industry. So in spite of the industrial connections being considered the most important, the actual research was mostly performed by YKI alone or together with academic partners. Already at this stage a recurring pattern of orientation both to academy and industry, but in different ways, is thus visible.

Very early on in the study period, the importance of good connections to STU was also mentioned, with the secretary of the Industrial Committee, Haldor Lervik, stating:

This close connection with the surroundings, primarily the Foundation for Surface Chemistry Research and the Swedish National Board for Technical Development, represent a steady source of inspiration for the institute's research activities, and guarantees that our efforts are oriented around the solution of important and real societal problems. (YKI annual report, 75/76, p. 6, my translation)

The view that a close connection with the public research funders was important as a source of inspiration for the research did not really recur later on, however. Though the importance of public and later also EU funding was mentioned throughout, and such funding often exerted influence on the research program, this was not considered in terms of inspiration. Also interesting in the quote is the statement that YKI's efforts should be oriented towards societal problems – a more idealistic view than the far more common formulations of an orientation towards industrial or technical problems.

Through the 1980s, this state of affairs was mostly upheld as the institute grew and more and more industrial companies joined the association of YKI members/sponsors, and the share of industrial funding gradually became larger and more important than the money available from the government. It is mentioned that YKI has established itself as an important resource for industry with good direct connections, not in the least through personnel movements between the institute and industrial companies (mostly from the institute; a normal pattern was that newly graduated academics would work at YKI for a while before continuing to an industrial position) (YKI annual report, 86/87).

In 1989, the research at YKI was reorganised into five industrial sections (down from nine). The idea seems to have been to increase flexibility, as stated by the director in the 88/89 annual report: "The reorganisation has implied greater flexibility and better possibilities to combine our task to serve industry in our applications with development of even closer connections with universities in our basic research." (YKI annual report 88/89, p. 1). This can probably be understood as a response to an ongoing debate about the industrial research institutes, and as a way to 'protect' YKI against potentially hostile policy makers (the same pattern at the same time can be seen in the discussion of basic and applied research above). It can also be understood as a way to adapt the organisation to a strongly polarised research system in which an intermediary position is seen to be very insecure. It would then be important for the institute to have close connections with both poles. This positioning was of course not a new stance for YKI, but it was made a bit more explicit.

For the first fifteen years of the study, YKI thus grew in size but largely remained in its traditional role in relation to academia, state and industry, even if the proportion of funding coming from public sources gradually decreased for political reasons. But from 1990 and in the following years, a number of developments pointing towards an increase of heterogeneity as well as affinity with industry can be discerned. In the 1990 annual report, it was mentioned for the first time that YKI is doing more and more joint projects with industry. This must be understood as a step away from the traditional, more independent position and towards research performed together with industrial actors. In 1993, it was also announced that the number of such projects have risen from 1 in 1982 to over 20 in 1993. In the same vein, YKI also was ready to host guest scientists from companies, not just universities: "YKI is prepared to host guest scientists from member companies for longer or shorter periods of time. [...] YKI sees such an arrangement as a service to a member company and we believe that for the industry it is a sound investment in knowledge." (YKI News 2/93, p. 2) It was however also noted that such arrangements are still uncommon; the vast majority of visiting scientists come from academia.

In relation to this, it can also be noted that around this time the Surface Forces Group was set up as a way to institutionalise the cooperation with the Royal Institute of Technology. Performing mostly basic research, this group enabled sharing of equipment and staff between YKI and the university.

Something else that at least indicates an increased focus on industry over academia can be found in a detail from the annual reports. Up until the 1991/92 business year, YKI had used two statistics for reporting the amount of employed personnel: total number of employees, and number of employees with a higher academic degree. In the 1991/92 report, the statistic for employees with a higher degree was replaced by a statistic showing the number of people working, measured as full-time equivalents (see also figure 1 on page 49). In itself, this replacement of an academically-related statistic with one having more to do with economics and efficiency might not say too much, but it coincides with a lot of other developments indicating the same thing. It is also interesting as an example of how rather small details in the source material can be used to tell a bigger story.

Another development around this time, coinciding with the end of the Cold War, was that YKI was given permission to seek clients also outside of the Nordic countries (YKI annual report, 91/92). This can be seen as part of a general trend of increasing internationalisation following the end of major political polarisation in Europe – it became more important for all research performers in Sweden to orient themselves towards powerful actors in this new institutional landscape, most prominently the European Community (later the EU), not in the least to secure more funding. Nevertheless, it represents a shift in the development of YKI and industrial research institutes in general, considering that their primary purpose when set up was to support domestic industry. These changes are also nicely summarised in a quote from YKI News: "What started as a small Swedish Institute for Surface Chemistry has now developed into an internationally oriented centre with an excellent scientific reputation." (YKI News 1/94, p. 3)

A third development has to do with an increased orientation of YKI towards small and medium sized enterprises (SMEs). In the 1992/1993 annual report, it was mentioned for the first time that YKI were offering special services to SMEs (identified as companies with fewer than 200 employees in the 94/95 annual report), including a reduced fee for Foundation membership and a state-sponsored program aiming at the development of SMEs with limited experience of university educated staff:

Through the so called AMC-programme unemployed university graduates can be employed for development projects during six months. YKI appoints a scientific leader for each project and gives access to the facilities of the Institute. The cost for those participating in the programme is subsidized by the Government through labour-market political resources. (YKI annual report 92/93, p. 5)

This initiative can be linked to an active policy of the right-wing government that was elected in 1991 of supporting SMEs (Benner, 1997), and from this point on actively working towards SMEs became rather important to YKI. It can be seen as reflecting a more general shift in the understanding of how the research system should be organised, with high levels of technical knowledge being seen as important also in smaller companies. YKI continually received government subsidies for this type of work with Swedish companies. The excerpt from the 2000 annual report below is a clear description of how it would work:

YKI offers a wide range of customised services for small and medium-sized enterprises (SMEs). The aim of these activities is to strengthen the competitiveness of participating SMEs by increasing their technical expertise. This is achieved through problem-solving combined with a long-term strategic build-up and transfer of knowledge, primarily within the field of surface chemistry. The programme is subsidised by VINNOVA allowing Swedish SMEs to participate at a subsidised cost. (YKI annual report 2000, p. 7)

The trend towards joint projects with companies remained strong during the 1990s, implying a further strengthening of ties with industry, as for example the director expressed it in 1995:

The trend towards stronger links with industry has continued. Ten years ago, almost all research at the Institute consisted of independent projects, usually with some kind of government funding. Today, a large share of YKI's activities - more than 30 projects - are jointly sponsored by groups of companies. The steady growth in the number of such projects during recent years is an indication that they are a cost-effective way for industry to acquire knowledge in particular areas of interest. For YKI, involvement in such projects is a way to keep abreast of technological development in industrial branches. (YKI annual report 94/95, p. 1)

The final sentence is notable, as it inverts the more traditional argument that basic research and academic connections are needed to keep in touch with the academic research front. It probably indicates a rising level of technical competence within industry, making it relevant for YKI to keep track of developments there as well as in universities.

The general development of strengthening ties to industry is probably best understood as a response to a changing institutional landscape. With government funding becoming scarcer and future government support of the institutes seemingly remaining doubtful, it is presumable that YKI had to orient itself more towards industry and joint knowledge production, to secure needed financial support, but also more generally to find an organisational form for its knowledge production that could maintain long-term relevance. As an illustration, the following diagram shows the relative decline of the state (STU) share of base funding from 1985 to 1992:

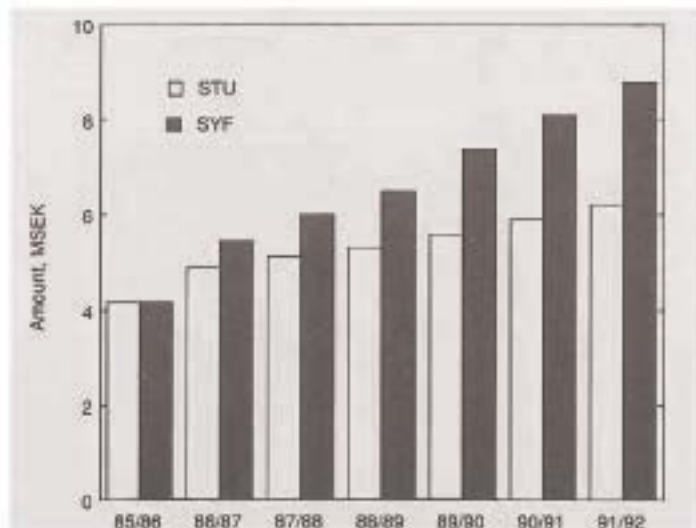


Figure 8. STU and SYF base research programme funding, 1985-1992. Source: YKI annual report 89/90.

Another organisational form, so-called 'competence centres', signalling another increase of heterogeneity, was mentioned in a 1996 issue of YKI News:

YKI has this year started activities in three special types of networks under the heading "Competence Centres" [...] As the name implies, such a centre consists of researchers from several academic departments working together with industry. Thirty competence centres, covering all areas of technology and the natural sciences, have been created in Sweden after an initiative from the National Board for Industrial and Technical Development (NUTEK). (YKI News 1/1996, p. 3)

Like the SME initiative, this is a policy initiative (consider the 'centres of excellence' mentioned in chapter 2) that YKI has become part of. This and similar programs are typical examples of a research policy focusing on innovation and non-linearity, so like the internationalisation of the early 1990s, it is indicative of a trend that is larger than YKI and even than the national context. At the same time, there were also network projects for purely academic basic research that YKI was part of, for example one project together with the Royal Institute of Technology and Lund University that secured funding for some basic research for several years.

In 1997 it was explicitly mentioned that the research at YKI was getting more and more heterogeneous both through joint projects with industry and through big EU-projects, and that this led to the creation of important new connections for the institute (YKI annual report 1997). Arguably this is networking of a different quality and scale than the traditional academic connections, which mostly focused on contacts between YKI and individual researchers.

No radical changes then happened during the late 1990s. Nonetheless, the decade had seen the institute changing, and starting to move away from its traditional role, in several important ways: it became more international and also started to take part in EU-projects, and its knowledge production became more heterogeneous as it linked up with competence centres and research networks. It also became more closely associated with industry. In many ways this can probably be understood as directly related to political changes. The internationalisation and EU-orientation became possible with the end of the Cold War, when Sweden's role as an ostensibly neutral country became less of an obstacle. Many of the new domestic associations of YKI were also political creations (some linked to the wage earner fund foundations). The closer

association with industry can also be understood as a way for YKI to link itself up with stable funding sources at a time when the state had little interest in industrial research institutes.

However, in 2001 a new policy decision regarding the industrial research institutes was taken (the 2001 government bill on research). After vacillating a bit on the future of the institutes, the government as mentioned announced a long-term interest in the institutes: they were considered important again, in line with the contemporary policy trend of non-linearity and a multi-dimensional research system. Interesting here is perhaps to note that in spite of the increased orientation towards industry and international actors, YKI remained rather sensitive to government decisions. Perhaps sensing the policy trend and the 'hot' terminology, it was reported that YKI continually worked to take part in different research networks, to support small and medium sized enterprises in Sweden, and to become a central actor in the Swedish innovation system (YKI annual report 2001). This same trend can also be noted in an article written by the chairman of the YKI board for YKI News:

YKI has established itself as a significant link between academic research in universities and applied research and development in industries. YKI has played an important role for the establishment of a professorship in surface chemistry at the Royal Institute of Technology (KTH). YKI has also strong links to many other universities and research institutes. YKI is an active partner for several successful networks not only on the national but also on the international arena. (YKI News 1/2001, p. 11)

The discussion about the future of the Swedish research system continued in 2002, with YKI emphasising that its strategic program, oriented towards different industrial sectors and with a good scientific foundations, would make it possible for them to remain an independent actor with good relations to other institutes and institutions (YKI annual report 2002).

2003 was described by the new director of the institute, Bruce Lyne, as a year of transition, from traditional forms of funding to a "greater emphasis on work for industrial clients and being appropriately paid for the value delivered." (YKI annual report 2003, p. 1) However, in 2003 this transition had arguably been going on for some time already. He also wrote that: "YKI's business model has always been to propose consortium projects to member companies wherein the consortium members wind up owning all of the intellectual property developed in the project." (YKI annual report 2003, p. 1) Although these joint consortium projects had been going on for some time, it is misleading to claim that it always has been YKI's business model – as demonstrated earlier, such projects were uncommon to nonexistent during the first decade of this study. Nonetheless, the claim illustrates the focus on industry, which is also demonstrated by the fact that the PhD program at YKI at this time was extended by one year to provide more time for industrial activities. Lyne's emphasis on industrial work continued also in 2004:

Operational income continues to transition from public funding to industrial income and the challenge is to expand the base of projects performed for industry to maintain balance as national public funding sources decrease support for the institute sector. (YKI annual report 2004, p. 4)

Exactly how this new relationship with industry was supposed to look is described in some detail in the 2006 research program (although this is formally after the end of the study, it is presented here as it is of quite some interest in regard to how YKI have tried to reshape itself in

the 21st century). According to this model, so-called 'enabling technologies' are supposed to flow in from YKI's (academic) network¹³, after which the institute matches them with customer and market needs, performs proof-of-principle testing and finally forms consortia with companies for the research and development. The diagram below illustrates the process:

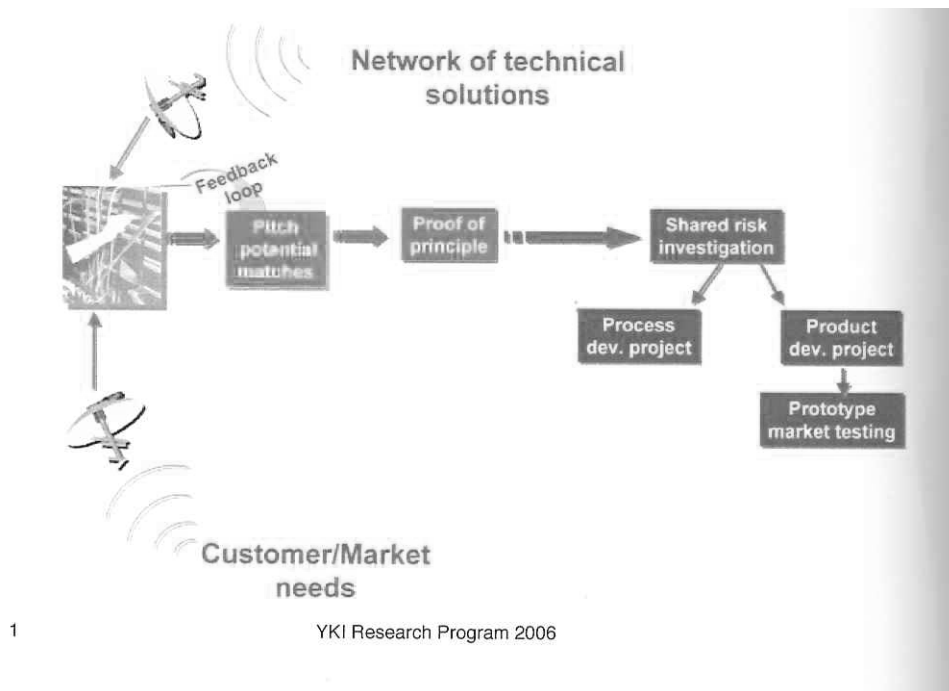


Figure 9. YKI's business model, 2006. Source: YKI Research Program 2006.

Both in style and content this model is very far from the mostly independent research institute of the 1970s and 1980s. It re-emphasises YKI's role as an intermediary organisation, while at the same time it very clearly focuses on work for industry rather than on the performance of independent or primarily academically relevant research. At the same time, the industry focus does not imply that the academic connections are ignored – as can be seen, they also have a role to play in this model, even if the orientation of the work has changed.

5.3.2 Interview findings, heterogeneity

Much as for the case of basic and applied research, the views on trends in the institute's external connections expressed by the interviewees are similar but temporally displaced to the trends discernable in the archive material. While the emphasis on an industrial orientation is notable at least from the early or mid-1990s in the archive material, Peter Alberius argued that in practice it is only in the last few years that more pervasive efforts to adapt the organisation in this way have been made. The general idea of the contemporary YKI being more focused on industry is corroborated, however. Academic connections are still seen as important to remain in touch with developments, but YKI itself should focus on industry and business (interview Peter Alberius).

This is also reflected in comments the interviewees made about the Fundamental Surface Science Group (formerly the Surface Forces Group), the institutionalised form of cooperation

¹³ While not further explored in this thesis, such a view is linked to an at YKI occasionally used motivation for basic research: that its performance is necessary to maintain what has been called 'absorptive capacity', i.e. the ability to identify, assimilate, and exploit external knowledge. A paper by Dżamila Bienkowska and Katarina Larsen (2009) discusses this concept in relation to (other parts of) the institute sector.

between YKI and the Royal Institute of Technology. Though originally set up as a clear part of YKI, focused around the new area of surface forces research, it has through its focus on more fundamental work gradually become more and more associated with the university, with weaker ties to the rest of (the more and more industrially-oriented) YKI (Interview Gilbert Carlsson; Annika Dahlman). Bengt Kronberg said it clearly: "It's almost like we can't consider it our own research, it's a little too far away. Regrettably." (interview Bengt Kronberg)

But the mutual orientation towards academy and industry is not invisible in the interviews. According to Bengt Kronberg, this related to the actors working within the institute, with directors Stenius and Holmberg essentially making YKI accepted as a serious research partner by academic institutions, with the scientific and academic orientation arguably being seen less important after their time. This is again in line with the archive material, even if the time of the shift towards a more singular industrial focus is placed at a slightly later time. Similarly, Irena Blute noted that from her perspective, the contacts with academia were more important early on in the study period:

KB: Would you say that [the relations with academia] have changed during the time you have been at the institute?

IB: There hasn't been a lot, eh, well, when I started, we had, there was a lot more university - this is my impression - a lot more contacts with universities, universities abroad. (Interview Irena Blute)

She also noted that YKI became significantly more industry-oriented towards the end of the study period. On the other hand, Kenth Johansson stressed that contact with the academic research frontier remains highly important for YKI even today.

The shifting role of YKI, from doing more of independent research to an emphasis on YKI as being integrated into larger networks, is also supported by the interviews. In one sense, YKI has always had a role of mediating between academia and industry, and the research programmes have always been more or less influenced by industry, but during for example the 1980s there was still more space for independent research and it was generally easy for YKI to find industrial support for research ideas. There was also less focus on sales (interview Gilbert Carlsson; Kenth Johansson). At that time, knowledge of surface chemistry was also generally lower within industry, effectively giving YKI a unique competence it no longer has in the same way (interestingly, Bengt Kronberg mentioned that when giving industrially-oriented courses in surface chemistry in the 1980s, it was common for companies to send their CEOs or research directors, while today they would rather send new employees).

Today on the other hand, YKI should more clearly play the role of intermediary organisation, taking in promising ideas and using them to 'meet' important problems within industry (interview Peter Alberius). This can be seen as a focus on knowledge transfer from external contacts (universities, but possibly also companies) to other external contacts (i.e. clients), with YKI acting as a kind of hub, its knowledge and competence making the transfer possible. And from the perspective of Annika Dahlman, YKI has started to focus more and more on consulting work, to the point of looking like it might become a consulting firm. This is fully in line with the views expressed in the research programs from the last years of the study.

The idea of a changing intermediary role for YKI was also explicitly addressed by Kenth Johansson who, in line with the description above, stated that the basic intermediary role for YKI hasn't changed, but the prerequisites for the expression of this role has, mostly for economic reasons:

We have always been a gate between academy and industry, that hasn't really changed. It's mostly really the conditions that have changed. And that depends on the general financing, today it's okay again, but for like five years ago or whatever, then it was really bad with respect to state funding [...]. (Interview Kenth Johansson)

Another interesting point brought up in the interviews relate to the increasingly international orientation of YKI, in particular following the political changes in the early 1990s and the growing importance of the European Union as a research funder. At first sight, this would seem to conflict with the basic role of the institute as a provider of relevant research for domestic industry. However, Peter Alberius argued that there is no conflict:

And [the high levels of international funding] are not in opposition to the owner's mission for the sector, because the institute sector has as its mission to strengthen the competitiveness of Swedish industry. But we do this by having world-class research, applied research, and the only way to judge, let me reformulate: our Swedish customers must be competitive on an international market and to be this you need to have access to a world-class applied research institute that is relevant on an international market. And the only way to verify that YKI has a competitive product, that our expertise is relevant, is of course that we compete on an international market. (Interview Peter Alberius)

Thus the internationalisation is not only a way to provide more work and funding for the institute itself, but also a way to ensure that the domestic clients are provided with research that is of a sufficient quality.

5.3.3 Summary of findings, heterogeneity

To provide a short summary of the findings relating to the archive material, it can first be said that the general trend is towards involving a greater number of actors, both in terms of funding and steering the research and of direct involvement in the knowledge production. The number of involved companies has increased, though chiefly in the first decade of the study, and the diversity among them too, going from a limited number of Nordic companies to a rather large and diverse group of companies from all over the world in 2005. Heterogeneity has also increased by YKI's participation in various research networks, centres of competence and similar initiatives. Diversity among the other funding institutions have increased as well, chiefly by adding the European Union as a main funder of research, in addition to the funds that have been provided by the Swedish government. However, in spite of this a second finding is that the diversity in terms of types of actors did not increase as much – throughout the study period, besides its public sources of funding YKI maintained connections primarily with industrial companies with an interest in surface and colloid chemistry, and with academic institutions doing work in these areas. The focus on industrial companies started to increase about halfway through the period and became quite dominating towards the end of the study. Finally it can be said that YKI's role shifted over the study period – from an early focus on independent, although industrially influenced or steered research (excluding the contract work performed directly for companies), to a latter focus on a more classic intermediary role: performing most research in consortiums with companies or within larger research networks, doing more confidential consulting work, and being more directly focused on sales and client needs. This relates to the fact that YKI in 2005 was competing on an international market rather than, as was the case in

1975, being relatively sheltered by the arguably generous framework agreements between state and industry.

Again, the views put forward in the interviews mostly confirm the picture painted by the archive materials, but with divergences in the timing of the identified trends. The idea that the role of YKI has shifted to a more network-focused and consulting role during the last part of the study period is corroborated by the interviews. There is also agreement that YKI has maintained an orientation both towards academy and industry throughout the study period, but with a trend towards an increased emphasis on industry during the latter part of the period. However, in the archive materials, this shift is discernable at least from the mid-1990s, whereas in the interviews it is seen as having happened mostly in the new millennium. Or more correctly, even if efforts have been made for quite some time, it is only in the 21st century that real changes have been effected.

5.4 Quality control at YKI

How has YKI measured the quality of its work during the study period? What trends can be seen in the employed measures? In particular, what has been the status of traditional academic quality control (i.e. peer-reviewed publications) during the study period? How do actors and researchers within YKI consider quality control? How, in their experience, has quality been measured at YKI?

Unlike the basic/applied distinction and the external contacts of the institute, quality control does not occupy a central role in the archive material reviewed. Though it is mentioned throughout, it is not discussed and motivated in the same extensive manner. This makes it impossible to construct a detailed narrative in the same way as was done for the basic/applied and heterogeneity themes. Nevertheless, by analysing what is included in the published material and how it is presented, it is still possible to draw a few conclusions. Most prominently, quality control at YKI has been dominated by traditional academic ways of evaluating research, i.e. peer-reviewed publications and conference presentations. Industrial relevance and appreciation have not been ignored as measures of quality, but they have played a comparatively smaller role throughout the study period. For this focus area, there are no significant differences between the archival findings and the interview findings.

5.4.1 Archival findings, quality control

In general, the bi-directional orientation towards academy and industry is also visible in terms of quality control. Throughout, examples are given of how increased industrial funding and new member companies prove the quality of YKI's industrially oriented research, while at the same time explicit mentions of quality control tend to focus on scientific quality and traditional scientific norms for quality control. This is in line with the tradition of industrial and scientific norms co-existing within the institutes. The emphasis tends however to be rather strongly on the scientific norms when it comes to explicit measures of quality, at least considering that the annual reports always include lists of e.g. academic publications and that publications and other kinds of scientific success stories are the most common examples of quality control measures in the material.

Indeed, publishing research results in academic journals seems to have been very important for the institute at least up until the end of the 20th century. The amount of published material is significant for an institute of this kind – in 2000, the institute reported 105 publications. The total staff at this time was 108 people, or 83 full-time equivalents, with not all of them doing research. Considering furthermore that a number of industrial projects are of a confidential nature, it must be concluded that the publication yield of the open research work at YKI has been very high, especially considering that YKI's primary purpose is to perform industrially oriented research. This certainly indicates that scientific quality has been seen as very important (though it should be kept in mind that this number includes publications from the more

fundamentally oriented collaboration with the Royal Institute of Technology – where researchers presumably would be much more likely to publish than in the average industrial research institute section).

That finding is also corroborated by statements in the annual reports, in particular from the latter half of the study period. The 91/92 annual report includes the following statement from director Krister Holmberg: “The majority, around 85%, of the work done at YKI falls into the category of open research, i.e. research to be published in scientific journals.” (YKI annual report 91/92, p. 1). In the same report, research director Bengt Kronberg stated: “In order to maintain a high international standard, the research is continuously evaluated through the publishing of scientific or technical papers as well as through the presentation of papers at international conferences.” (YKI annual report 91/92, p. 5).

In spite of this apparent emphasis on scientific quality and scientific norms, the institute did not ignore the dimension of industrial relevance as a measure of research quality. When presenting the 94/95 business year as a successful year for YKI, director Holmberg mentioned both industrial interest and what he called research output: “The year was successful in terms of research output and industrial interest.” (YKI annual report 94/95, p. 1) The research output was given a clear measure – 75 scientific publications, and more lectures and reports than ever. However, as another measure of the success it was also mentioned that the institute has attracted six new member companies, coming from as far away as Australia and the United States, which illustrates the international competitiveness of YKI.

This general trend of a bi-directional orientation, with emphasis on scientific quality when quality control is explicitly discussed, continued throughout the study period. In 2002, the commitment to scientific quality appears to have been stronger than ever:

In fact, a strong presence of YKI in the scientific debate through publications or conference presentations is important for the future success of YKI, since this provides a means of quality control and can help to attract both new member companies and research collaborations. (YKI research program 2002, p. 1)

According to this view, scientific publication provides a means of quality control that will make YKI a more attractive partner, presumably by demonstrating the high level of scientific competence of the institute. This is rather interesting, as it seemingly contrasts with findings from the two other focus areas, in which YKI by this time appeared to be more oriented towards applied projects of industrial more than scientific relevance. Yet the same sentiment is expressed also the following year: “A cornerstone of YKI’s long-term strategy is emphasis on scientific quality.” (YKI research program 2003, p. 3) At the same time, that research program also contains a nod to industrial relevance: “Just as important as instrumentation and scientific quality, however, is the ability to place science and results in an industrial context.” (YKI research program 2003, p. 3)

Considering the number of publications during the study period in relation to this, the continuing focus on scientific quality is however not visible:

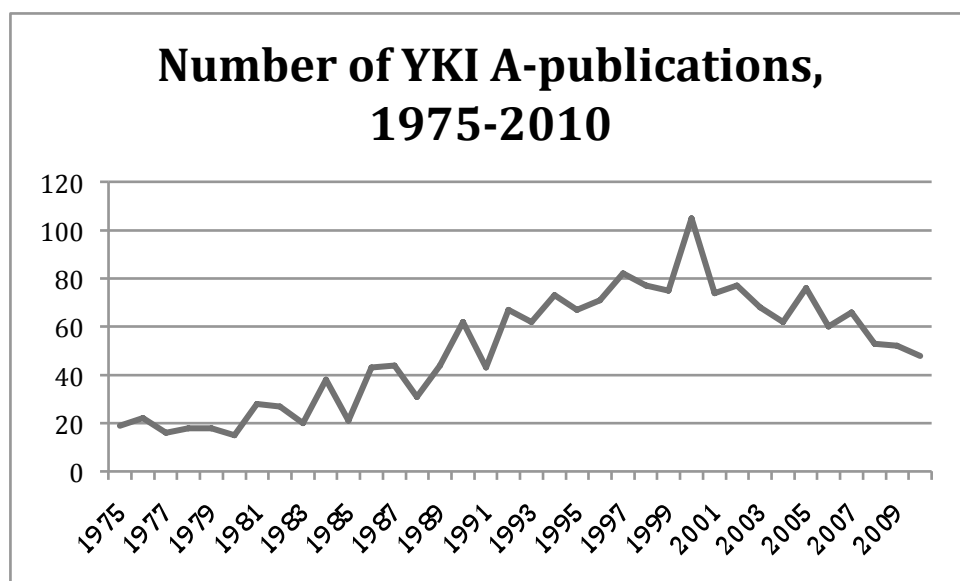


Figure 10. Number of A-publications at YKI, 1975-2010. Source: YKI publications database, <http://www.yki.se/en/library/publicationdatabase/Sidor/default.aspx>

The A-publications of this graph are traditional, peer-reviewed academic publications, such as journal articles, book chapters, doctoral theses etc. Looking at this graph, one could then assume a profoundly lessening importance of scientific quality after the peak in 2000. However, one must be careful not to over interpret these numbers. YKI decreased in size at the start of the millennium, which explains part of the decrease. Also, it is plausible that a rather small number of researchers could have contributed a large share of the publications, on account of for example an extensive professional network. In that case, the departure of a single person from YKI could lead to a quite significant decrease. Similarly, an unusually high number of PhD students during one period could lead to a strong increase. On the other hand, the decrease could also be related to an increased share of confidential contract work, thus signalling a re-orientation of YKI's priorities.

5.4.2 Interview findings, quality control

The historical importance of scientific quality is corroborated by all the informants. For example, Gilbert Carlsson stated that during his first period at YKI, in the late 1980's and early 1990s, the focus was on demonstrating scientific quality through publications and presentations:

GC: If one takes that period, 84-94 or 95, then the focus was on creating material that was good enough to be publishable and presentable at conferences, scientific conferences, and that is then a kind of stamp of quality, showing that the research as such is done at a certain level. If it then is usable or not is a different matter.

KB: But it was the scientific part that was in focus?

GC: Yes, precisely, it was the scientific part that was chiefly in focus, in that it was said okay, the goal is so-and-so many reviewed articles, journal articles, and a certain number of presentations, I remember I had that as a goal, that I should present at at least two international conferences per year and so on, that doesn't really exist [at YKI] today.

Thus the focus was clear: the research should be of a demonstrable scientific quality, something that is not the case at YKI today to the same extent. There were no other explicitly stated measures of quality that Carlsson could remember from the 1980s. If anything, success in securing new financing from industry was seen as a demonstration of industrial adequacy of the research. Annika Dahlman put that same impression very succinctly: "It was measured in profit." (Interview Annika Dahlman) Similarly, Irena Blute remembered that the focus was on publishing, and also said that this focus recently has become less pronounced as YKI has started to do more and more confidential, and thus unpublishable, work.

This emphasis on scientific quality was explained in different ways. Perhaps most importantly, scientific quality was seen as important for attracting clients (interview Bengt Kronberg), a view that was also presented in the archive materials. This apparently remained true throughout the study period, with the orientation away from scientific quality as the main focus in this area only started when YKI became part of SP in 2006 (interview Peter Alberius). Another explanation relates to individual actors within the institute. Most prominently, director Per Stenius was seen as the main champion of the scientific orientation. His personal interests and disposition tended towards the academic (interview Bengt Kronberg; Kenth Carlsson), but he also saw the strategic importance of building up a sound scientific base at the institute (interview Bengt Kronberg). According to Bengt Kronberg, this had been necessary to avoid a collapse of the institute once a certain level of base knowledge had been transferred to industry. At any rate, much of the scientific orientation can probably be seen as a result of Stenius' work, which also to some extent spilled over on his successors (interview Bengt Kronberg). Linked to this, Annika Dahlman suggested that another reason for the orientation to scientific norms (and the high levels of basic research) can be related to the fact that YKI was established out of an interest to explore a relatively uncharted research field, thus giving academics at the institute a rather large freedom to shape the knowledge production, at least early on (as opposed to a new institute set up in a field where it is already well established what can be done).

The continuing emphasis on publications can also be seen as related to the idea expressed by Faulkner and Senker (1994) that academics outside of the academy might still have their own reasons to conform to academic norms. According to Annika Dahlman, it has not been uncommon for YKI personnel to have academic career aspirations, and thus they would strive to publish a lot for this reason:

You know, they, the directors have aimed for a professorship, actually, to a large degree. I mean, Martin [Malmsten] is a professor, and also section managers have aimed for, become, professors, some of them. It has been their career, so it's understandable that they would've thought so. (Interview Annika Dahlman)

But even if scientific quality was emphasised throughout the study period, industrial adequacy was not ignored. YKI researchers presented their work at applied or industrial conferences in addition to more scientifically oriented ones, and close attention was paid to industrial feedback on research and to the ability to secure new industrial financing. Nevertheless, there were no explicit measures of research quality in this sense; such measures always focused on the scientific quality (interview Bengt Kronberg).

5.4.3 Summary of findings, quality control

To start with the summary of the archival results, both more traditional scientific quality control, such as publication in peer-reviewed journals or conference presentations, and industrial relevance and industrial appreciation appears to have been seen as indicators of what good YKI research is throughout the study period. Such a co-existence of academic and

industrial norms might be typical for industrial research institutes – at least such a historical tradition exists (Kaiserfeld, 2010). What is probably less typical is the rather strong emphasis on the scientific norms that can be seen within YKI. It appears clear that academic publishing and other forms of academic activities retained a high status at YKI for all of the study period. Indeed, unlike the findings relating to the other two focus areas, there are no obvious trends of change relating to quality control. The number of YKI publications has gone down recently, but this can be explained by various other factors, and the commitment to scientific quality appeared to remain strong even after the year 2000.

For the quality control focus area, the archive findings are largely identical with what was put forward in the interviews. Interviewees agreed that scientific quality has been in focus throughout the study period – at least from 1977 when the academically-oriented Per Stenius became director – with a turn away from this having only happened very recently, and mostly in 2006 and later, after the present study ends (while standards have indeed changed at the time of writing this thesis and there probably is some overlap, this does indicate that the decrease in publications between 2000 and 2005 is not primarily a result of a reorientation of the institute's standards). Still, informants also acknowledged that industrial relevance and appreciation to some extent have been considered to be indicators of good research, but in a much less systematic and structured way than for the scientific quality control. Neither in the interviews nor in the archive materials are there thus any clear trends of change identified for this focus area.

5.5 General summary of findings

Before proceeding to the analysis of the findings, an attempt at a synthesised recapitulation will be made here, in which the three focus areas will be considered together. From such a starting point, the main finding seems to be that YKI gradually, and very significantly after the turn of the millennium, has increased its orientation towards industry. While the institute always has had such a foundation, relating to its mission as an industrial research institute, the emphasis on direct industrial connections and cooperation has increased. This is expressed both as a decrease in the importance of basic research within the institute and in YKI's changing role and relationship to industry. It is however not readily discerned in the third focus area – scientific quality seems to have remained the main way to evaluate and judge the research throughout the period.

This correlates with the generally decreasing levels of state funding and an ambivalent political stance towards the institute sector. Even when state funding did increase, it did so in a context where it struggled to keep up with industrial funding and – as would have been well known at YKI – where state support to the university sector increased significantly more. The political situation was often – either explicitly or more implicitly – referred to in YKI annual reports, indicating that changes in direction at the institute were linked to this broader political context.

A summary of developments within all three focus areas can also be found in table 6 on the next page:

Table 6. Summary of findings for all focus areas.

	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005
Basic/applied	Institute generally committed to autonomous basic research in addition to its applied and contract work		Emphasis on basic research decreases, more focus on its association with technical problems; it remains <i>de facto</i> very important		Further decrease of emphasis on basic work, more and more presented as a side phenomenon. Actual levels of basic research also start to notably go down	Basic research given even less emphasis, still sometimes considered important but far from in focus, actual levels keep going down
Heterogeneity	YKI working closely with academia and industry but is to a large extent an independent knowledge producer			Notable increases in heterogeneity and affinity with industry; increased internationalisation; participation in policy initiatives	Continually increasing focus on close cooperation with industry; participation in EU projects	Strong emphasis on industrial contacts; YKI taking on a more classic intermediary role
Quality control	Standard academic norms (peer-review) is the most important measure of quality, somewhat complemented by industrial appreciation and funding					Publishing remains very important but perhaps starting to be less so; number of A-publications per year going down

Besides these general developments, a number of more specific findings of the study also deserve to be further highlighted. They will be presented in brief below, but also returned to in the analysis that follows:

- *The informants' generally clear distinction between basic and applied research* is arguably one of the findings that is most interesting also in a wider context. All but one of the interviewees understood basic research and applied research as meaningfully referring to distinct types of work. While they would also mention that the two could occasionally overlap or relate closely to each other, there was no indication that they saw the categories as merging together, nor that, as Jane Calvert's work would otherwise suggest, they are not very useful for researchers describing their work except as rhetorical devices in the interaction with funders and policy makers.
- *The difference in the descriptions of the role of basic research at YKI between the archival sources and interviews* is another highly interesting finding. While the importance of basic research at YKI is gradually but clearly downplayed in the annual reports and the research programs from the mid-to-late 1980s and onwards, several informants convincingly stated that levels of basic research had remained high at the institute throughout the 1990s.
- The *changing intermediary role of YKI* was already touched on above. This finding essentially amounts to recognising that, while always in an intermediary position with respect to academia and industry, the expression of the intermediary role has changed. Compared to the start of the study period, YKI was much more closely associated with its industrial sponsors at the end. The knowledge production gradually became more focused on collaborations with industry and on confidential contract work, as opposed to the more independent research that characterised the institute early on. One way to put this could be that YKI gradually has become more of an intermediary in the classic sense, and less of an independent knowledge producer.
- Another result is about the gradual *internationalisation of YKI*. At the start of the study, the industrial foundation was open only to companies from the Nordic countries, of which Swedish companies were the clear majority. From the early 1990s, this geographical restriction was removed, and while Swedish companies remained in the majority, the geographical diversity increased and YKI was clearly much more internationally oriented at the end of the study period, with an increased dependence on international clients and also on participation in EU projects. This is in particular interesting when related to the political goal for the institute sector, which was and is to support Swedish domestic industry.
- Domestically, one finding is that YKI has tended towards *alignment with policy trends* in at least some cases. Important examples of this are the services provided to SMEs from the early 1990s and onwards, or the participation in different research networks and centres of competence when such initiatives became fashionable (and funded). Both examples became somewhat important for the institute. This finding highlights and supports the idea that industrial research institutes can adjust to new norms and standards with relative ease.
- However, the opposite is also visible: sometimes, YKI has tended towards *non-alignment with policy trends*. The most salient example of this was touched upon above: while the policy towards the institutes have for all of YKI's existence been that they should perform mainly applied research, the institute has nonetheless performed significant amounts of basic research at a very high scientific level.
- Another factor that has shaped the developments at the institute is the *early uniqueness of YKI's knowledge*. The laboratory, which later became the institute, was set up to provide a surface chemistry competence that at the time did not exist in Sweden. During the early study period, competence levels in the industry were very low and there was

no other place in the country to which companies could turn for help with problems relating to this field.

- Another finding, discernible in the archival sources and made explicit by informants, is that *the directors of the institute have had a lot of influence on its knowledge production*. Most notably, director Per Stenius built up and strongly promoted basic research and an academic orientation at YKI. While this probably was far-sighted and beneficial for the institute, it was also acknowledged by the informants that Stenius in this regard was driven by his personal interests and disposition.
- The next-to-last point to be taken up here is in no small part the result of Stenius' work, namely *YKI's strong publishing culture*. While industrial appreciation and new industrial clients and projects have also been considered signs of a high research quality at the institute, this has been less important and considered in a less systematic way than academic evaluation methods. For an in principle non-academic research institute, YKI has published significant amounts of work in academic journals and at academic conferences, and the commitment to this publishing culture remained strong throughout the study period (even if it is less strong at YKI today).
- Finally, one would not do justice to the institute without pointing out the *relative success of YKI*. It should be remembered that YKI, like the other institutes (although YKI might have had an advantage in being quite broad, rather than oriented exclusively to one branch of industry), has been a very small player existing in an environment that has given rise to a great number of challenges. The difficulties in navigating the institute through a political and institutional landscape where the support for its organisational form has been hesitant at best, in maintaining a balance between internal competence and external demands, and in transitioning from being a largely base funded institute of 1975 to being an institute fully exposed to international competition in 2005, should not be underestimated. That fact that YKI still exists and maintains a good reputation thus makes it possible to claim that the institute's management of its knowledge production for the most part has been purposive and successful.

5.6 Analysis of findings

One fruitful way to understand the results presented above is to conceptualise the developments at YKI as being driven by struggles for, over and with relevance. Hessels' idea of relevance as benefits to society has in this case been narrowed down by the motivating idea behind the industrial research institutes: they should benefit society through supporting industrially-relevant technical research. Even so, it might sometimes make sense to distinguish between political (demonstrating relevance to policy makers) and industrial (demonstrating relevance to industrial companies) relevance: often but not always similar or overlapping forms.

Over the study period as a whole, the struggle is continuously expressed by YKI trying to find a role for itself that would enable its long-term survival – that is, the institute has continuously struggled for relevance in a changing political and economical landscape. This struggle, it can be argued, is what has been behind the increasing heterogeneity of YKI knowledge production, for example by aligning the institute to current policy trends, as could be seen in the cases of the services directed towards SMEs or in the participation in centres of competence, or by seeking funding from new sources such as the EU. It can also be considered to be behind the changing role of YKI in the research system, with the institute trying to find the best position from which to relate to companies and other sources of funding, and to be behind the changing motivations for basic research and the generally increasing focus on applied research, with the institute more and more working on problems of direct relevance to industry. With regards to quality control, it has continued to be guided by scientific excellence as defined by academic standards. However, the absence of clear trends away from the focus on scientific quality is not a counterindication of the general development: it could be that industrial and other actors indeed

continually have seen scientific quality as being the most relevant way to judge the quality of YKI's work – or that there has been less pressure to change in this area, given that the research funders nevertheless have been able to use levels of funding and choice of projects as parallel feedback measures. The latter appears more likely: while, as Staffan Jacobsson (2002) notes, tacit knowledge and indirect benefits are usually more important than codified knowledge (i.e. publications) for companies to benefit from academic research, in the case of YKI the relations were always close enough to enable these indirect benefits anyway. Thus there would be little reason for companies to see it as troublesome that YKI also published a lot of its research. Also, academic publishing has maintained or even increased its importance for scientific institutions, including research institutes (Sörlin, 2006).

In this way, it is possible to use the conceptualisation of an ongoing struggle for relevance in a changing environment to explain the described developments at YKI, and the appealingly simple picture that is the outcome is by all indications for the most part valid on a general level. Considering the study period as a whole, the trajectory of YKI's developments can indeed be well understood as being the outcome of an ongoing struggle for political and industrial relevance, in which YKI has had to adapt to standards that it had little power to influence. But this also obscures a number of things. As an example, the most interesting question with regards to the results about basic and applied science at YKI is perhaps not really why the emphasis on applied science has increased over thirty years, but rather how it was possible for an industrial research institute to keep performing a lot of high-level basic research for such a long time, especially as the institute in question was established at the time when the political goal set for the sector was changed to emphasise applied work. The question relates to something that could be called YKI's degree of freedom. Simply put, by portraying the historical dynamics of knowledge production at YKI as the outcome of single-minded adaption or attempts at adaptation of perceived political or industrial standards of relevance, one misses out on the fact that there have been other agendas in play as well, which depending on the context have been able to exert notable influence over the knowledge production and its organisation.

To mention the most obvious factor first, the more base funding allocated to free research the institute has had, the more free has it been to set its own research agenda. This is however almost trivial and not too important in this context, because with the funding agreements being renegotiated every three years, YKI could only stray away from what its funders would see a relevant research at its own peril. More interesting here is what above was called the uniqueness of YKI's competence. When the institute was first set up in the 1960s, this was done to alleviate the lack of surface chemistry expertise in Sweden, and for quite some time, there was a lack of even basic knowledge within industry, effectively making YKI a unique resource. It is likely that this gave the institute a lot of influence in early struggles over relevance, i.e. in defining relevant surface chemistry research, and in that case the institute did not simply adapt to external standards of relevance, but helped set those standards. Even as the institute sector as a whole was pushed towards more applied research, YKI was during these years able to keep performing, and even able to increase its level of, basic activities. It is likely that this to some extent can be explained by the fact that the institute itself had a relatively large influence over what was seen as relevant, so that the basic projects were something everybody wanted even as the political winds changed direction.

It is important to realise that the word struggle in this sense does not always imply an explicit conflict between two differing agendas. For example, during approximately the first decade of the study, there was within the institute as well as within its industrial partners generally strong support for the performance of basic research to build up a solid knowledge base in surface chemistry. There was no apparent struggle in the everyday sense of the word; not two antagonistic positions that had to be reconciled. In this case, it was rather easy for YKI to be

relevant. This also ties in to the findings of Faulkner and Senker (1994) – industry does not always automatically see applied as more relevant than basic. While this is speculative, the later changes in YKI knowledge production might well be understood as adaptive to an industry that no longer needed or wanted basic research *from YKI* to the same extent as before (because they no longer felt that they needed it, because they had learned to do their own research or because they could obtain it from elsewhere), in addition to political pressure to become more applied in line with how policy actors considered the role of the institutes.

The example of basic and applied research also relates to a third way in which the knowledge production was shaped in other ways than simple adaption, namely the role that individual actors within the institute sometimes played. While it must be cautioned here that actors in leading positions did not appear out of nowhere – directors were for example appointed by the board (and by implication, accepted by the owners) – but rather in a sense embodied the direction that the owners currently wished the institute to continue in, the findings do indicate that there have been strong actors who have been able to promote a personal agenda to at least some extent. The most prominent example of this is by most accounts director Per Stenius, who during his 14 years of leading the institute left a profound mark on its work, successfully taking it into directions it most likely would not have gone had it simply been trying to adapt as well as possible to external standards of relevance. Stenius was a strong promoter of basic research and academic norms, something that made it possible for YKI to build up a reputation of being an institute operating at a high scientific level. While it is not fully clear from the sources how deliberate and conscious this was, it was a strategy that probably made it easier for the institute to keep on presenting itself as a valuable partner even as more and more surface chemistry knowledge was spread throughout industry. Of course, in this sense it can be understood as adapting to a future situation in which YKI would have to keep proving their relevance to an industry with more and more knowledge of their own – but it was still proactive, not reactive.

So it is possible to interpret Stenius' orientation towards basic science, academic credibility and scientific quality as far-sighted and beneficial for the institute in the long run (even if no definite conclusions can be drawn from the material studied here), but it is hard to see it as being driven primarily by the desire to adapt. Perhaps it can be said that he, to a larger extent than most people involved with YKI, really was a natural scientist in the sense of this rather apt quote from Hessels' thesis:

Natural scientists themselves are ambivalent about relevance. Promising societal benefits can help to acquire necessary resources, but it can also restrict their autonomy and creativity, which counts as central values in their work. (Hessels, 2010, p. 9)

One example of how Stenius' agenda for YKI was wider than adaption is the appeals to the importance of autonomous basic research that are quite common in the archive materials from the first decade of the study. They are statements about the nature of research and innovation, but on another level they can also be considered claims in defence of basic research, parts of a struggle over relevance. Of course, when something needs to be defended, there is generally either a perception of it being under attack or an expectation that it is about to be attacked. And defending is something else than adapting.

Another indication of this is the discrepancy between the YKI publications and the interview results when it comes to the decrease in importance of basic research. On the one hand, there is a clear trend in the published materials that basic research as such is getting less space and less unambiguous support from the late 1980s or at least the early 1990s. The number of pages dedicated to it in the annual reports decrease and the motivations for it increasingly focus on

how it can be closely associated with particular technical problem areas. On the other hand, according to several informants, levels of actually performed basic research remained high throughout the 1990s. As stated above, this can be seen as part of a struggle for relevance where YKI downplayed its more basic activities, or at least tried to emphasise their closeness to applied research, to make its work appear more relevant to external actors. Still, one should careful not read too much into this. It should especially be avoided to believe that YKI somehow could 'hide' its real research program from its sponsors – that was hardly the case. The point here is subtler – the existence of such a discrepancy itself indicates that the institute was aware that its work differed from some outside standard or expectation, which might have been 'in the air' more than in the form of actual criticism of the research program. It can for example be seen in the focus on tangible industrial applications in the 1983/84 annual report, when the institute was concerned about an ongoing parliamentary discussion of research funding, a use of the idea applications and of applied science that is in line with Jane Calvert's work.

Should the continuing focus on scientific quality at YKI also be understood as a result of an agenda that did not primarily focus on adaption? It might look like that, but it is arguably a bit more complicated. Consider the following diagram (figure 11), which contrasts the percentage of base funding provided by public sources (STU or NUTEK) with the number of academic publications per year, from 1989-1997 (it works well as an example, but the particular period is motivated by something as dull as a limitation regarding the continuity of the data series):

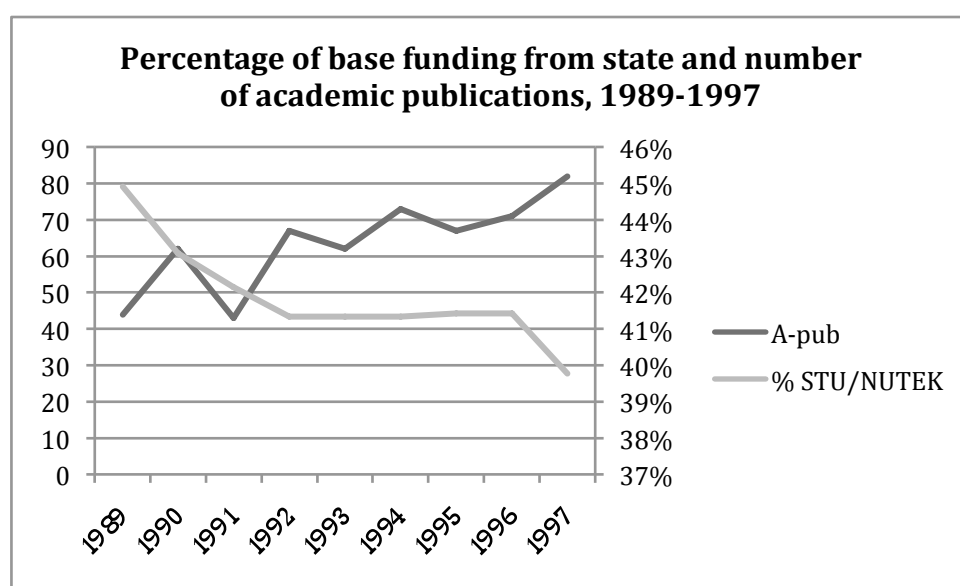


Figure 11. Percentage of base funding from public sources and number of A-publications, 1989-1997. Source: YKI annual reports.

Although there is a clear trend of declining base funding from state actors – the funding most associated with basic research – the number of publications are steadily climbing. The easy way to understand this graph would be that YKI, perhaps because of the impression left by Stenius, was so committed to scientific quality (represented by academic publishing) and basic research that it kept on with it instead of adapting to the negative trend of the funding most associated with free research. There is truth to this – by most accounts Stenius' successor as director, Krister Holmberg was able to use his good connections to secure funding that enabled YKI to keep doing much basic research. Likewise, there has undoubtedly existed a strong, and compared to other institutes very strong, publishing culture at YKI. However, it is not unproblematic to deduce this from the graph. For example, some of the increase in the number of publications can be explained by the fact that YKI grew during the period. And, perhaps more interestingly, there is no direct relationship between number of publications and level of basic

research. Although quantitative studies of science often equate publications with basic research, this cannot be done for YKI, which according to a statement by Holmberg from 1992 in principle should publish 85% of its research, a figure that naturally includes much applied work. What the graph does show is a continuing commitment to publishing. But this might as well be understood within a framework of adaption, as being related to a generally increased emphasis on publishing, both within universities and research institutes. At least it might be assumed that there was no serious pressure on YKI to move away from publishing its research results as long as the research itself was seen as relevant by funding actors (this has however changed recently, after the end of the study period).

Another example that can be considered in these terms is the increased internationalisation of YKI. One way to understand it is to see it as an expansion of the client base, desirable as a way to secure more funding and to diversify funding and work sources. However, this appears to conflict with the political goal of the institute sector – supporting domestic industry – and thus could threaten the political relevance of the institute. In this regard, one fully appreciates the comments of Peter Alberius about how international competition is a way to make certain that the domestic industry is provided with internationally competitive research: YKI's international orientation is in this way understood as politically relevant (according to Sverker Sörlin (1991), the interpretation of international contacts in national terms is very common in science). Whether or not this has always been an explicit motive of the internationalisation remains an open question.

To summarise, what has been argued here is that the findings described above can be understood as the outcome of an ongoing struggle for relevance, in which YKI has tried to ensure its long-term survival by finding a viable niche for itself in face of a changing research system and a hesitant policy attitude. On a general level, this struggle can be understood as a process of adapting to external standards and ideas of the role of an industrial research institute. However, even if the general trajectory of YKI can be understood like this, it must also be emphasised that not every development of YKI has been driven by a desire to adapt. A unique competence or strong and well-connected actors within the institute has given sometimes giving the institute more space to shape its own developments: it can be seen how YKI then has defended its positions by engaging in struggles over relevance, or by trying to present its research somewhat differently from how it really was organised. This has shaped the institute significantly and might, though this has to remain an open question, have been more beneficial than a pure adaption strategy in the long term.

Finally some remarks on the results in relation to Mode 2 theory can be made. Although the study explicitly avoided seeking to confirm or reject this theory, it has nonetheless generated results that belong to the same domain, so it seems appropriate to simply consider what the results have to say. Looking first at the attribute of context of application, some support for the Mode 2 thesis is discernible, notably that the distinction between basic and applied is less than absolute in the archive materials; that it is often pointed out that basic research can (and should be) be closely linked to particular applications; that there is sometimes space for both basic and applied research within the same projects; that applied research can provide input to new basic projects; and that the categories sometimes can overlap. On the other hand, most informants clearly considered basic and applied to be distinct categories of research, and even if they sometimes are closely related or situated within the same project, there are no clear indicators that the categories as such are merging at YKI. So even if most research at YKI to some extent always have been determined by the context of application (something natural for an industrial research institute) there is not support for all of the changes outlined in NPK.

For the heterogeneity attribute, there is also some support. Research at YKI has become more heterogeneous throughout the study period. Yet also here the support is not without ambivalence: in particular, the diversity in terms of different types of actors involved in YKI research has not increased too much. Universities and industrial companies remained the dominating actor types throughout, with public funding agencies also being important but less directly involved in the knowledge production. However, this is likely related to the specific nature of YKI as an industrial research institute.

With regards to quality control, there is no support at all for the Mode 2 thesis. Traditional academic publishing dominated at YKI throughout the study period. While industrial relevance and appreciation have also been important, these indicators are automatically available to an industrial research institute, and hardly signify novel forms of quality control in the Mode 2 sense.

While not studied, some remarks can also be made on the transdisciplinarity attribute in relation to the study. Arguably, an industrial research institute, less constrained by traditional academic disciplines and always working in a kind of application context, with problem areas defined with the help of industrial input, would be a suitable arena for transdisciplinary research. While the present results do not allow for any conclusions in this respect – it would require studies situated closer to the actual research practice and probably also more domain knowledge – industrial research institutes could be kept in mind for further research as organisations where transdisciplinarity might be found and could be studied. This could also help clarify the nature of transdisciplinary research, given that it can be hard to understand from the literature (see e.g. Weingart, 1997 for some remarks on the concept) how it could work in practice.

Overall, this is a mixed bag, quite similar to other empirical reviews of Mode 2. There are changes, most notably with regards to heterogeneity, but it is hard to see any support at all for the more radical predictions from NPK. At best, the knowledge production at YKI can be understood as being a kind of hybrid of Mode 1 and Mode 2, but whether or not further Mode 2 developments are to be expected in the future is beyond the scope of this study. Also, YKI cannot be understood as having started out from a clear Mode 1 position: as an industrial research institute, it has always had an orientation to applications. The hybridity instead largely comes from sticking to academic evaluation standards and from not going completely in a Mode 2 direction with respect to the other two attributes studied. This also implies that a coherent development of the attributes together is not identifiable, as the Mode 2 theory would suggest.

However, even if the case of YKI does not look like it has been changing exactly in line with the theory, it still confirms the underlying idea of Mode 2: that changes in society will be observable as changes within scientific institutions. Knowledge production at YKI has indeed changed as society has changed, even if the changes do not look exactly like what the theory outlines. In other words, YKI has changed as part of a changing society (whether or not society has changed in the way suggested in *Re-thinking Science* will not be speculated on here) that arguably has spoken back with a louder and louder voice. This is of course not a radical result: if science studies have taught us anything, it is that science and society are intrinsically linked to each other, and industrial research institutes can be said to have even tighter couplings to society in this regard. But radical or not, the details of YKI knowledge production during 30 years present an interesting case of how a research institute has struggled to remain relevant in a changing science system. Hopefully, the work presented here has been able to throw some light on how these details have looked and what they entail.

6 DISCUSSION

This chapter is devoted to a discussion of the study and its results. It will begin with a discussion of the findings in relation to the aims of the study. This also includes a brief, slightly more theoretical discussion of the basic/applied distinction in relation to the findings. Then a few remarks on the research strategy and methods employed will be made, including a discussion of their implications for the study and of possible alternatives.

6.1 Discussion of findings

In the previous chapter, the findings of the study were described and analysed in relation to the research questions. This section will be devoted to a brief discussion of how these findings relate to the goals and expected contributions of the study.

Considering first the general topic of the study, that is, to explore and understand knowledge production at YKI from 1975 to 2005, the study provided results relating to three different aspects of knowledge production: the role of and distinction between basic and applied research, the external connections of YKI, and the quality control of the institute. Taken together, the results present an image of an institute that has struggled to remain relevant in a changing research system, but which also at times has had a certain amount of room to frame its own developments. The concept of struggles of relevance was introduced as a way to understand this: both the more general dynamic of adaption and the occasions when YKI has rather struggled to defend its research program or niche. This conceptualisation highlights the importance of being able to align, or at least present itself as being aligned, with prevailing standards of relevance. In this way, the findings and the analysis satisfy the research topic. However, one limitation is that the study only considered YKI 'from the inside', something that unavoidably leaves out certain aspects of the institute's struggles for relevance. By diversifying the empirical material studied, a more fleshed-out account could have been given that likely would have satisfied the research topic even better. This is however an issue with the research strategy chosen and so will be discussed further in the next section.

It was also expected that the study would be able to provide input to ongoing debates about changes of knowledge production. It has done so primarily by demonstrating how the knowledge production of one particular case has changed over thirty years. An increased knowledge of this case is seen as a valuable result in itself, and it fills a knowledge gap with regards to the history of YKI. But it is also hoped that the study will be able to inspire to further research. The findings seem to add more evidence to the idea that it remains hard to explain the ongoing changes of knowledge production in terms of existing grand theories, at least in terms of Mode 2. It thus seems important to keep adding knowledge about how changes actually have taken place at local sites. One rather interesting line for further research would be to keep exploring changes in knowledge production on the level of individual organisations and in terms of struggles for relevance. In particular, the tension between a perceived need to adapt and a desire not to, and the consequences of this, seems very interesting. It cannot be said for sure, but considering only the case of YKI it might be that a pure, adaption-only strategy is not the most successful in the long-term. At any rate this deserves further work: some ideas about this and other possible lines of research will be presented in the concluding chapter.

With regards to the second stated goal, namely that the study should contribute to the ongoing project about research institutes at the Royal Institute of Technology, it has done so by providing the historical details of some developments at one of the institutes. Through this, our knowledge of the niches and roles of the institutes has arguably increased. Although it is not new knowledge that the institutes have changed over time, the present study provides more insight into how this particular institute has changed (or in some regards, has not changed): what niches it has

found itself in and which roles it has taken on. Even if it is impossible to generalise from one case, the case in itself leads us to a better understanding of the history of the Swedish industrial research institute sector.

Can the findings also be utilised for making normative statements on research and innovation? The answer here unfortunately has to be no. Compared to the study of Hessels (2010), which does make policy recommendations, the present thesis is both shallower and narrower. Its focus on a single case, and even more so its focus only on sources internal to the studied institution, would make any normative claims shaky to say the least. Furthermore, there does not seem to be a lot of normative conclusions to draw. Perhaps an argument could be made that YKI has benefited from its history of focusing on basic research and scientific quality more than what is common among industrial research institutes and more than what policy has promoted, and perhaps normative remarks could be formulated from this idea. But is problematic to equate what is good for YKI with what is good for society, and even more problematic to draw normative conclusions only from ideas about what is good for YKI. Thus, the thesis will refrain from formulating normative statements or policy recommendations.

Finally the distinction between basic and applied research will be given some attention. As noted, this matter gave rise to some questions already in the chapter on the theoretical framework: does the demarcation make practical sense at all, or is it just an invention made for statistics? Is it not often the case that the two are intertwined, and cannot basic research yield applied results, and vice versa? Is it correct to downplay differences between them? Is basic research even needed for applications? It is clear that the categories have figured in many different roles in this thesis: we have seen them work as rhetorical figures, as pragmatic definitions used to sort interests and as categories used by actors inside YKI to describe the research that they actually do. What are they really, and what do they mean?

In a sense they are of course all of this. It seems well established that they have a rhetorical dimension; that they can be used as resources to solve political problems or to argue for more funding or for lower expectations on practically useable results. But interestingly, in the YKI material analysed and, more importantly, to the YKI researchers interviewed for this thesis, they also seemed to meaningfully describe different kinds of research. Even if it was acknowledged that the categories can overlap, that basic and applied research feeds into each other and that most basic research at YKI was of an oriented character (clearly something natural for a research institute in which paying companies exert a certain influence over the research), the majority of the informants upheld a distinction between research aimed at generating new knowledge and research aimed at applying knowledge to a problem or problem field.

In itself, this fact is interesting as it contradicts Calvert's (2006) finding that scientists would mostly not use these terms (only basic research, in the case of her research) to describe their own work except in connection with assessments or when looking for funding (one possible reason for this is that Calvert explored the term basic research, which might be harder to identify with than the for the most part oriented basic research at YKI). But as with most results of this study, it is impossible to take it out of its disciplinary and institutional context and to use it to form either general conclusions applicable to research policy or well-founded contributions to the ancient debates over and about the two categories.

Nonetheless, the fact that the categories seemed to have some meaning for YKI researchers makes it sensible to keep paying attention to them and to the distinction between them. A complete merger of the categories, as Mode 2 would have it, does not seem to have happened at YKI, which as an industrial research arguably is one of the places where such a development would first be visible. On the other hand, a binary opposition is impossible to uphold. Claims that we have either the one or the other, and that a focus on one comes at the cost of the other, do not

reflect a reality where basic and applied can be very closely related even as they remain separate. Formulating the distinction in terms of an absolute dichotomy does indeed seem “crude and outdated” (Tijssen, 2010, p. 2), to borrow Robert Tijssen’s phrase. But where does this lead?

Considering only the work presented here, it is hard to get beyond the OECD definitions of pure basic research, oriented basic research, and applied research. Even if the terminology varies somewhat, these are the three kinds of research described in YKI materials and by YKI employees. And at any rate, as explained above this case study cannot provide solid ground for the construction of any kind of general taxonomy (but of course that was never the intention either). But maybe that is just as well. Is it really a fruitful approach for an analyst to construct a top-down framework into which research is afterwards to be fitted, or made to fit?

Perhaps it can be, and perhaps that is a rather ungenerous description of such work. But at any rate, an alternative can be sketched, starting from the fixed point that is the use of the categories by researchers. Even if there is a lot of scholarship that downplays the differences (Roll-Hansen, 2009), basic and applied research have not disappeared as actor’s categories, at least not at YKI (of course, this does not mean that they are *natural* categories: it is entirely possible and even quite likely that the use of the categories at YKI and elsewhere stem directly from their use in policy – but this does not preclude that they have a function in organising research). So one way forward is to continue Calvert’s work of paying attention to how researchers in different fields and at different local sites of knowledge production use the categories, what functions they fulfil, how they help order and organise research, and how they relate to research practice. This would entail asking questions about how terms such as ‘basic research’ or ‘linear model’ function and organise work at different local sites, not questions in the style of ‘what is basic research?’ or ‘is there a linear model of innovation?’. By in this way considering what the terms actually do, it might be possible to get both a clearer image of them and ultimately also a more solid foundation for how they ought to be dealt with by policy.

6.2 Discussion of methods and research strategy

Following the above discussion of the findings in relation to the goals of the study, this section is devoted to a discussion of how the study was performed, to what was and was not included and the implications thereof. Perhaps the most pressing matter to discuss here concerns the choice of material for the study. The focus was on material – annual reports, research programs, and newsletters – primarily produced for an audience outside of the institute itself. This material, though in many ways revealing, does not say anything about considerations and opinions of the main actors within the institute that were deemed irrelevant or unsuitable for publication. Arguably, the same things could to some extent also be said about more traditional source material, for example board meeting protocols, but such material would still give more insight into e.g. decision-making processes or particular turning points in the strategy of YKI. Even if the interviews to a certain extent ameliorated this deficiency, it was naturally not possible to interview all relevant actors from the study period, so there is still a knowledge gap in the study in relation to the more internal workings of YKI.

There are a couple of things that can be replied to this. The first is that the choice of material to a certain extent was pragmatic. For a project of this scope, it is necessary to quite strictly limit the amount of material being used, and the set of materials presently analysed had two advantages in this respect: it was of a reasonable size, and it was already available and systematically ordered for the entire study period, something which can not be said about every type of YKI document. A second reply is that even if the study does not tell the entire story of YKI, it does tell a story that is interesting in its own right. Indeed, no historical account can ever give a fully exhaustive picture. Making choices is the only viable way to work. An assumption of the present

study was that a focus on this material – which remains rather telling with regards to how YKI wanted to present itself – along with interviews to perhaps fill in any glaring knowledge gaps would be able to form the basis of an interesting and valuable account of knowledge production at YKI, as long as one remains aware of its limitations.

In relation to the above, another point to discuss is the more general choice to focus only on sources internal to YKI. This choice was based on the perception that such an approach is uncommon in the present domain, and so was an attempt to do something new. Nevertheless, it had an impact on the findings on the study. Most notably, the absence of external material makes it impossible to fully elaborate the historical case and thus to fully explain the dynamics of knowledge production within YKI; to fully understand the institute's struggles for relevance and how these struggles have been shaped by outside events and actors. Or to put it differently, YKI did not exist in seclusion, and it would be a mistake to understand the developments at the institute as being isolated responses to aloof policy making. There was always a dialogue between YKI and the other actors and this perspective is to a certain extent missing here. But again, restraints on the scope of the study were necessary, and the choice to focus on internal sources seems justified, considering the range of previous research. Thus, this is simply another limitation that has to be kept in mind.

A few remarks can also be made about the interview part of the study. The aim of the interviews was to complement the archive study by getting the perspectives of actors who had worked at different positions within YKI during the period. This aim must be considered to have been realised – the interviews did complement the archives nicely, for the most part confirming the findings while occasionally providing a more nuanced or even different view of the developments. There was also reasonable diversity among the informants, with perspectives provided both from the top management level, from mid-management and from research engineers. Still it would of course have been valuable to interview more people – in particular perhaps one or more of the old directors of the institute – but this became impossible for time reasons.

Although what the informants focused on and the examples they used naturally differed depending on their position (for example, the top-level informants were naturally able to speak more about the 'big picture' and YKI as a whole), in the context of the research questions there were few considerable differences between them except as was clearly presented in the findings (the only two notable examples are that Alberius and Kronberg stated that basic research had been important through the 1990s, a view not shared by everyone, and that unlike the others, one informant did not clearly see a decrease in the emphasis on basic research through the period as a whole). This arguably supports the validity of the interview findings.

Even though the motivations behind the choice of YKI as the case for the study were presented in chapter 1, this choice can also be briefly discussed here. There are a number of different industrial research institutes, all with their own history, profile and scope, and there is no doubt that they all would make for interesting study objects in their own right. The choice of YKI was based on its scientific profile (making it interesting in relation to the function of the thesis as a PSTS graduation project), the fact that it had not been extensively studied before, and the rather pragmatic reason that it is situated close to where the author was located. This does not seem problematic. Arguably, the only point of criticism that can be raised against the choice is that the author has no particular competence neither in surface or colloidal chemistry nor in chemistry in general. However, this lack of domain knowledge would have been there no matter which institute had been chosen, and at any rate, the aim of the study did not relate to the technical details of the work at YKI but more to the organisation of research at the institute. With this focus, the lack of chemistry knowledge was not problematic.

Another important point that should be mentioned relates to the fact that there was no investigation into the actual practice of research at YKI. This was an active choice, motivated not in the least by the fact that it would have been practically impossible to acquire the necessary knowledge of the research field in a short enough time. But it has one particular consequence that needs to be taken up here, most significantly in relation to the work on basic and applied research. The thesis deals with these categories as they are described in the archive materials and by the interview participants. It cannot say anything about how these concepts have related to the practice of research beyond what these two sources have offered. Essentially then, a statement such as ‘work at YKI has become more applied during the study period’ amounts to saying that ‘according to an interpretation of the source materials and interview transcripts, work at YKI has become more applied during the study period’. The point here is not to caution that this interpretation might be flawed, but to draw attention to the fact that it remains an interpretation of certain sources, and that basic and applied remain categories used internally instead of categories produced by an analysis of performed laboratory work. In other words, the point is to highlight that the claims about changes in knowledge production made in this thesis are made based on (or mediated through) YKI discourse and not on an independent analysis of research work.

In this respect, there is a kind of structural tension in the text, between the aim to investigate changes in YKI knowledge production on the one hand, and sources that for the most part only reveal how changes in knowledge production at YKI have been communicated on the other¹⁴. This tension does not go as far as to subvert the stated aim of the thesis – taking also the interviews into account, the conclusions that are drawn about actual changes seem to be tenable, given that the interview discourses on knowledge production were linked to actual work at YKI – and can in fact sometimes be rather revealing, as when there is a clear discrepancy between the source materials and the informant’s descriptions, but it is nevertheless something that needs to be kept in mind. At the same time, that the thesis can and does say a number of things relating to how research has been described, and how the categories of basic and applied research have been used in such descriptions as well in the general discourse used in YKI texts, has a high value in its own right.

Finally, some attention can be given to the general research strategy employed and in particular two things left out by the study. The research strategy chosen for this thesis was motivated by a desire to fill a knowledge gap, both with respect to YKI itself and to the inner workings of an industrial research institute during the last thirty years. This has already been discussed at some length and needs no further motivation or defence. However, it must be acknowledged that this choice in helping to fill one knowledge gap also creates new ones; that the narrative it has resulted in is not the only possible one. Thus two approaches that together or by themselves might have resulted in a different image of YKI – two paths not taken, as it were – will be briefly discussed here.

“Questions of epistemology are also questions of social order.” (Latour, 1993, p. 15-16) This, as Bruno Latour asserts, has been the slogan of the strong programme of the sociology of scientific knowledge. A highly radical thesis, it puts in focus precisely what the present work has excluded: questions of epistemology. If it is reformulated for this thesis, it loses some of its force:

¹⁴ It is presumably possible to read the annual reports of YKI more or less directly as indicators of how the institute has perceived current research policy trends. While such a reading is already present in this thesis, a more systematic and thorough analysis with this perspective as an explicit starting point, perhaps also including comparisons with other institutes, would be very interesting for a follow-up study. That would provide a highly interesting image of how policy making was understood from inside the sector (Thanks to Ingemar Petterson for pointing this out).

Questions of research organisation are also questions of social order. It seems less devastating, perhaps even self-evident. But it nevertheless highlights an important part of understanding the developments at YKI, already touched on above: without a full account of the history of YKI's social context; of the social order that institute has been a part of, the historical dynamics of its research organisation cannot be fully understood. This is not pointed out to undermine the conclusions of the thesis, but to serve as a reminder of the ways in which they are limited, and that a more externally oriented approach might have led to different ones.

Playing around with the aforementioned slogan also brings light to the second path not taken: Questions of research organisation are also questions of instrumentation. At least for the case of YKI, this statement seems to be correct. Instruments of various sorts are highly important to the performance of surface chemistry, matters of instrumentation were a recurring topic in the annual reports, and acquiring various instruments and competence in their use have always been important parts of YKI strategy. It was also clear from the interviews that changes in instrumentation, in particular the gradual introduction of more modern and computerized equipment, has had a profound impact on the organization and performance of research at YKI. This perspective was not taken up at all in the thesis, again mainly because of restraints on time and scope, and also because more knowledge about the domain most likely is needed to do it justice. Nonetheless, it is very much a knowledge gap that deserves to be filled, but it is also almost a world of its own; a world that "bridges research and engineering" (Gaudillière, 2004, p. 185), and as such a topic that is big enough to need its own project. It goes as far as to raise questions about the nature of science and its relation to technical instrumentation and competence in its use. Here it will only be acknowledged that this perspective is missing, and that the story of YKI could have been a different one had it been included.

To conclude, this section has discussed a number of issues both related to the study as it was performed and to matters not included. The aim of the more critical paragraphs has not been to question the value of the study, but to draw the reader's attention to its limitations, to make it clearer what it does and does not say, and to perhaps show areas where further work could fruitfully be situated.

7 CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The overall aim of the study was to explore the dynamics of knowledge production within YKI from the mid-1970s until 2005. This was done through a study of certain archive material from YKI in combination with interviews with YKI employees. In this final chapter some conclusions relating to this aim will first be presented, and the thesis will then end with some suggestions for further research.

7.1 Conclusions

Given the analysis and discussion above, the conclusions can here be put rather briefly. Firstly, it is possible to conclude that YKI's knowledge production has generally changed in a way that made the institute more closely, and in a different way, oriented to its industrial clients at the end of the study period compared to the situation at the beginning of the study. This can be clearly seen in the focus areas of basic and applied research (decreased emphasis on basic research) and heterogeneity (more emphasis on work directly for industry; new role in the research system). For the focus area of quality control, no clear trends are visible, but as discussed above there are many potential reasons for this that does not make it contradict the conclusion.

Secondly, it is possible to conclude that the general dynamic described in the first conclusion is the outcome of a struggle for relevance in which YKI has had to adapt to the absence of clear political support and to gradually decreasing state funding by trying to align itself with the latest policy signals as well as with more stable sources of funding. The main expression of this struggle is the increased industry focus, but it also includes e.g. engagements in policy initiatives or work to secure EU funding.

Thirdly, it is possible to conclude that in spite of a general dynamic of adaption over the study period as a whole, not all developments at YKI has been driven by a desire to adapt to external standards. Sometimes the institute, having a unique competence base or strong and well-connected actors in central positions, has had more room to run its own actors' agenda even if these have not been aligned with the prevailing standards. In these cases, the institute has engaged in struggles over relevance or has made efforts to make its work appear relevant in its published material. This has had a significant impact on the institute; the main example is the strong basic research agenda that the institute was able to maintain until the late 1990s in spite of decreasing base funding and political support.

7.2 Suggestions for further research

To end this thesis, four different lines of possible further research will be suggested, tying in both to the ongoing project about industrial research institutes and to more general contributions to theory. The first suggestion is, unsurprisingly enough, that more research should be devoted to the case of YKI. While the present work has been a first step, much can be won by broadening the source material used and expanding the study to also consider material from other actors and institutions that have related to the institute. In this way, a more complete understanding of the developments, and of YKI in the larger innovation system, can be reached. Another highly relevant approach, already mentioned above, is to study the role of instrumentation in YKI knowledge production. This role has been significant and deserves elucidation.

A second suggested line of research is to make further case studies of other industrial research institutes during the same time period as was considered here. This would generate fodder for comparisons between institutes and make it possible to discuss the reasons for different similarities and dissimilarities between them, something that will be interesting in its own right

but that will also help understand the developments of the sector as a whole. In particular, it would be very interesting to study possible differences between 'new' institutes, such as YKI and SICS, and the older ones. It is possible that some aspects of YKI's research organisation and knowledge production can be explained by the fact that the institute was established rather late. It would also be interesting to make comparisons on the basis of the fields in which the different institutes work. For example, developments at YKI were almost certainly affected by the fact that there early on was almost no other surface chemistry research or competence in the country.

Moving beyond the Swedish industrial research institute sector, a third suggestion is to keep exploring changes in knowledge production, on the level of different kinds of research institutions working in different disciplines, in terms of struggles for relevance. In particular, a continuing focus on how institutions have handled struggles for relevance historically and how they handle them now seems interesting and would complement Hessels' (2010) mostly individually-focused study. One fruitful consideration, at least looking at the present study, would be the tension between a perceived need to adapt to new standards and a desire (and perhaps possibility) not to, and the consequences of this. A line of research such as this could also benefit from the introduction of more organisational and institutional theory than was used here.

Finally, the fourth suggestion pertains to further work on the basic/applied distinction. While there are many different directions such work can take, here the starting point is the existence of basic and applied research as apparently meaningful categories for YKI researchers. It would be very interesting to pay closer attention to exactly what researchers mean by the terms and how they relate to how work is organised and practised, at YKI and in any other local site of knowledge production where they are used. The application of ethnomethodology to this problem would arguably be one very promising way to proceed.

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Appendix A: Interview guide

Note: This interview guide is fairly generic and should be adapted to the current informant as needed.

- Introduction, presentation of the study, biographical data
 - Background at YKI – time, roles, relation to YKI knowledge production
- Focus areas
 - Basic/applied
 - What is the meaning of these concepts for the informant? What is the relation between them? How would he/she use them?
 - How do they relate to his/her work (and to the work of YKI as a whole, if applicable)? Examples from own research?
 - How have the meaning and the relation changed over time? Why? (e.g., connection with other changes, if applicable)
 - Heterogeneity
 - How would the informant characterise the role of YKI in relation to industry, academy, state and to eventual other stakeholders? Has this changed over time?
 - How would the informant consider his/hers own work in relation to these external connections? Has this changed?
 - Quality control
 - What is good research for the informant? How does he/she know if something is good research? Does this differ from the idea of useful research? Examples from own research?
 - How would the informant judge whether or not an YKI project is good research? (maybe probe for e.g. publications or industrial relevance, and changes over time)
 - Are there any official or implicit standards within the institute for what constitutes good research, e.g. journal publication, industrial relevance etc? If so, has this changed with time?
- End of interview
 - Is there anything the informant would like to add in relation to the interview matter?
 - Thanks for participating etc.

The above is a general structure and a guideline for the interview, not a fixed list of issues. The actual questions will be adapted to the interview situation and the actual responses and comments of the informants will shape the course of the interview. Particularly interesting answers, or topics that the informant clearly likes to talk about, might be explored more in-depth.

Appendix B: List of acronyms and terms used in the text

A-publications	Category used by YKI library for peer-reviewed publications (journal articles, book chapter, doctoral and licentiate dissertations, etc.)
FOSAM-committee	Committee studying the role of universities in the research system and how they could work as the 'research institutes of society'. Report presented in 1980
FYF	The Association for Surface Chemistry Research, YKI's non-profit industrial association. Replaced SYF in 1995
IRECO	The holding company that managed state involvement in the industrial research institutes and restructured the institute sector. Since 2009 known as RISE
IVA	The Royal Swedish Academy of Engineering Sciences
IVL	Swedish Environmental Research Institute
KOFI	The committee for restructuration and reinforcement of the industrial research institutes. Report presented in 1996
KTH	The Royal Institute of Technology in Stockholm
NPK	<i>The New Production of Knowledge</i> , the well-known book by Michael Gibbons and colleagues that introduced the notion of Mode 2 knowledge production
NUTEK	The National Board for Industrial and Technical Development, the agency that replaced STU in 1991 as the state representative in the industrial research institutes
OECD	The Organisation for Economic Co-operation and Development, an international economic organisation
PSTS	Philosophy of Science, Technology and Society, the master program within which this thesis is written
RISE	Research Institutes of Sweden, since 2009 the new name of the holding company that organises state involvement in the industrial research institutes (see IRECO)
SICS	The Swedish Institute for Computer Science
SME	Small- and medium sized enterprise
SP	SP Technical Research Institute of Sweden. The mother company of YKI

STFI	Swedish Wood Research Institute, today known as Innventia
STS	Science and technology studies; very broadly speaking a research field concerned with problems relating to the relationship between science, technology and society.
STU	Swedish National Board for Technical Development, the main government agency involved with technical research. Also the main public actor concerned with the industrial research institutes, the counterpart to SYF and the main public financier of institute research. Together with several other agencies it became NUTEK in 1991
SYF	The Foundation for Surface Chemistry Research. Organised industrial involvement in YKI research, the private counterpart to STU. Replaced by FYF in 1995
VINNOVA	Swedish Governmental Agency for Innovation Systems, administering state funding for R&D
YKI	The Institute for Surface Chemistry