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Innovation, Firm Strategy & Government Policy: *Why and how they should be linked*

FS&P Ph.D. Thesis no. 10/1996

ISSN no. 0909-9174

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Ph.D. Thesis
PhD Program in Technology Policy, Innovation and Socio-Economic Development.
Department of Social Sciences
Roskilde University
March 1996

Summary

Firm strategy and government policy need to be linked in order to foster innovation. This dissertation develops a theoretical perspective, that aims at explaining and guiding real-life innovation and technology policy (ITP), through providing an interpretation of why this link is needed and how it may be achieved. This is accomplished by combining a variety of approaches, which are synthesised and related to each other.
The main message is that firms differ, and that the strategy formulation process by its dependence on company history and specialisation tends to reinforce this firm heterogeneity. As a consequence, ITP should engage in a dialogue with the firms in order to come up with policies that are relevant to this diverse recipient community. Such a bottom-up perspective may have three key advantages over the more traditional top-down approach. Thus:

- Government will by asking the companies be better informed about the *true needs* of the business community.

- Creating a dialogue is a very important part of generating national strategies that will carry broad enough consensus and political support to result in a process that may become self-reinforcing

- Interactive learning-processes between governments and businesses, among the several participating companies are stimulated. This may result in the creation a common terminology that often may be lacking in government-business communication.

On the other hand, bottom-up policy formulation may create new kinds of problems, due to

- Information asymmetry

- Problems of aggregating micro-level results

- The inherent selectivity in choosing some but not all companies to enter into a dialogue, and finally

- The inevitable inability of firms to articulate some needs that involve a tacit component.

To address these difficulties a concept called User Defined Innovation and Technology Policy (UDITP) is developed. This approach calls for a specific implementation form that complements the bottom-up formulation process. By offering companies a wealth of policy schemes from which they may freely choose only a limited number, one may - it is argued - at least partly address these problems that emerge in bottom-up ITP formulation.
By drawing on a recent Danish ITP analysis exercise, the Resource Area Analysis (RAA), the relevance of the approach is illustrated and further two concrete tasks of contemporary ITP are identified:

- To ensure companies with good framework conditions, which are factors that lay outside the firm's boundaries, but are requisite in its production process to sustain competitiveness.

- To uphold and sustain absorptive capacity - "the ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends[1]" - at the national level (NAC[2]), as well as ensure firms actively engage in search processes.

Finally, it is argued that ITP needs to be integrated with Technology Assessment (TA), in particular with a recent approach called Constructive Technology Assessment (CTA). This 'school' argues that time has come to undo the two-track approach to stimulation and control of technological change (innovation), since the social change *process* that innovation involves, cannot be separated from the *act* of bringing a new product, process or service to the market. This approach is the final link in the 'seamless web' of arguments that all call for broad, dialogue-based, bottom-up forms of policymaking. The approach as a whole makes one thing very clear: It is the single firm and its needs which deserve centre stage in the debate on innovation, and the best government can do is to become a catalyst.

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[1]Cohen and Levinthal (1990, p.128)
[2]NAC stands for National Absorptive Capacity, see Wegloop (1995, p.419).

Acknowledgements

The writing of this dissertation has been a painstaking, but rewarding effort to which many people have contributed both directly and more indirectly.
Firstly, I would like to thank the NUFFIC for initial financial support through a *cultural agreement* between the Netherlands and Denmark, and the VSB Bank for a scholarship/loan. Thanks also go to the Department of Social Sciences at Roskilde University, which through granting me with a research fellowship in 1994, (PhD-stipendium) enabled me to finalise the thesis without financial worries troubling me.
Many people, especially those connected to the PhD Program in Technology Policy, Innovation and Socio-Economic development at Roskilde University, have provided theoretical input to the dissertation. These include: Esben Sloth Andersen, Youngrak Choi, Lars Fuglsang, Helge Godoe, Nguyen Thanh Ha, Per Hetland, Jesper Alex Jørgensen, Michael Kluth, Frank Skov Kristensen, Torsti Loikannen and Mogens Kühn Pedersen, John Zysman.
A special thank you goes to Dan Gelvan, colleague, best friend and eternal source of inspiration for always being willing to listen and through never-ending discussions provoke me to write something which is relevant in real life to real people dealing with real issues[1].
Special thanks also go to Peter Lotz, of the Copenhagen Business School for being willing to take on the demanding job of being a committee member. Morris Teubal of the Hebrew University in Jerusalem also accepted this task, and in doing so could witness the 'preliminary-end-result' of a project of which he has been a primary and continuous source of inspiration. It thus was during my BA-studies in Israel that my interest in the field of the economics of innovation started by attending his classes, and it was him who encouraged me to afterwards attend the MA Postgraduate Programme in technology Policy and Innovation Management at MERIT (Maastricht Economic Institute of Innovation and Technology) in the Netherlands.
Jon Sundbo, chairman of the committee, is the main responsible for putting me 'back on track' after the necessary theoretical travels one has to make in order to obtain a PhD. After he became my supervisor in late 1993 there has never been any doubt as to my finishing the endeavour I started, and I thank him for his patience and the stability he brought into my work.
Most important contributors to this thesis are however my friends and the members of my family who helped me to endure in the exhausting effort a dissertation becomes at different stages.

[1] In doing so, he made me refute the inscription of a dissertation by van Witteloostuijn (1990) where it reads: "A dissertation is to be written not to be read".

My grandparents deserve thanks for their financial support in times of trouble, while my parents have always supported me in the career choices I made even when these sometimes seemed mysterious.
My parents in law in Denmark made sure that I never felt I 'missed my family', since I simply had one here.
This thesis would never have been completed were it not for the support of my wonderful wife Mette. She has always 'been there', and never allowed the occasional PhD-crisis and its inherent negativity to rule our lives and forced me (rightfully) to enjoy the family life we have together. There is only one way I can think of to thank her for the sacrifice it means to have a PhD-student for a husband, and that is by bringing into this world more children together that resemble the first miracle we jointly created: Stella. I am glad she only had to have a stressed PhD-student for a father for around 10 months, and thank her for providing me with a joy in life that I cannot put into words. It is to these two women in my life that I dedicate this dissertation, hoping I can mean to them what they mean to me.

Philip Wegloop

Preface: The O.J. Simpson Method of Academic Research

Recently, in the 'murder trial of the century', American football hero O.J. Simpson was acquitted for the brutal murder of his ex-wife and boyfriend, which took place in 1994. Millions of people around the globe followed the trial *live* on their TV screens, and formed their own opinion as the guilt or innocence of the defendant in the double murder trial. With the trial over time increasingly focusing on racial issues[2], the question of guilt or innocence mostly seemed to be answered along racial lines, with a white majority in favour of a guilt verdict and the black communities believing in O.J.'s innocence. Throughout the trial, it became clear to me and many other people, how the American legal system functions. As one should hope in a modern society, law and order are determined by certain 'rules of the game', that until revised due to internal/external pressures form the basis for deciding on guilt or innocence. While the task of the prosecutor is to build a case which proves to the jury the guilt of the defendant beyond 'reasonable doubt', the defence lawyer(s) tries to show the very existence of 'reasonable doubt' as a minimal strategy. Both sides do so, by telling their 'story', and bringing in witnesses that testify as to the validity of this version of what happened. Both sides can cross-examine each other's witnesses, and the credibility of the witnesses is crucial to convince a jury of guilt or innocence[3]. During the trial the judge makes sure, that the 'rules of the game' are followed and intervenes when necessary to guide lawyers, prosecutors or the jury in/away from certain lines of reasoning.
In my view, the process of writing a PhD thesis, submitting it to the evaluation committee and defending it resembles, or rather should resemble the above process very much. ¨

[2]O.J.Simpson is an African American.

[3]This dissertation is not about the O.J. Simpson trial per se, and as such I won't enter the 'hot issue' of whether a predominantly black jury acquitted him unrightfully on the basis of their own prejudices.

In the analogy[4], the roles would be divided as follows:

Judge Ito	The supervisor: Jon Sundbo
O.J. Simpson	The dissertation project
The Prosecutors	The evaluation committee: Jon Sundbo, Morris Teubal and Peter Lotz
The Jury	The evaluation committee: Jon Sundbo, Morris Teubal and Peter Lotz
The Defence Lawyer[5]	The author of the PhD-project: Philip Wegloop

Stated in terms of the analogy my task as defence lawyer, is to present my story in such a manner to the committee - by using credible witnesses (good bibliography) and solid evidence (relevant and empirical data) - to be able to show academic research ability 'beyond reasonable doubt'.
This analogy shows is two main important facets of PhD work as I see it.
Firstly, it shows that while the reader may disagree with the outcome of the project, he/she still can approve of the way the story is told/presented. Most important is thus the 'storyline', and way of building a credible case, rather than actual normative implications of the research project. This presupposes establishing a plausible link between theory and evidence, and a sound method of collecting the evidence[6].
Secondly, and most importantly, there is a clear distinction between the process of writing a thesis (the 3/4 years of working on it) and defending it (writing in final form). Thus, as well-known to all scholars, during a research process one nearly always discovers that the original research questions should/could be rephrased, and more precise and better hypotheses could be developed. If however, one would in fact adjust the research questions continuously, chances are one would never submit a final PhD-project in the form of a dissertation, since it is **always** possible to improve[7]. The dilemma facing the PhD-student reminds of that facing the firm which has to balance static and dynamic efficiency. While exploring new potential sources of competitive advantage is crucial to the survival of every firm, this should not take place at the expense of exploiting existing potential along the way. Similarly, I view the PhD-project as a first step on a long never-ending road, but at some stage - no matter that better routes may still be chosen after even longer deliberation - it is wise to *get on the down the road* !!

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[4]The analogy does of course not hold entirely as illustrated by the double roles of some of the actors. (Another difference is that the supervisor at times has to take on the role of the devil's advocate!)
[5]I wouldn't dare to claim a further analogy here in that the 'dream-team' of defence lawyers that surrounded O.J. Simpson have their counterpart in me as the ideal defender of PhD-theses in general.
[6]That the latter is crucial may be illustrated by the Los Angeles police department's sloppy handling/collecting of evidence, which may have played a major role in the eventual acquittal of O.J.Simpson

1

Introduction

1.1 Towards the research question: background for the project

> Ultimately, good science is good conversation between good people speaking well.
>
> J.T.Mahoney (1992, p.104)[8]

In the social sciences, the initial research questions that one brings into a PhD-project only rarely are the ones that one ends up answering or explaining when finalising. Research is a process and while being engaged in it, one sharpens the understanding of the problems at stake, and in doing so changes the very questions that demand answering/explanation.
This world-view where initial research questions are only *guiding posts* to the really interesting issues, according to my opinion prescribes the use and generation of 'descriptive theory' (Yin, 1993). This type of theory

> *...is not an expression of a cause effect relationship. Rather a descriptive theory covers the scope and depth of the object (case) being described (Yin, 1993, p.22).*

Thus this type of theory puts the initial research questions into context, determines the 'frame of reference' and **eventually comes up with the issues that are of importance to the topic of study.**

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[7]As we shall see in the dissertation, it is a central part of evolutionary theories that evolutionary processes inherently look wasteful in hindsight.
[8]Adopted from McCloskey (1985).

This dissertation is an attempt at generating such a descriptive theory, that defines the issues of importance to the formulation and implementation of real-life contemporary innovation and technology policy (ITP). This is accomplished by means of a synthesis of several theoretical approaches, and as such the approach is multi-disciplinary and eclectic in nature.
Originally, this dissertation started out as trying to solve the research question

> **What are the implications of evolutionary economics for technology policy ?**

This research question was the *culmination* of work written under the supervision of Morris Teubal during my BA-studies at the Hebrew University of Jerusalem, and subsequent inspiration from the evolutionary economists at MERIT[9] where I completed MA.
After writing an MA-thesis with the title: "On the why, when and how of technology policy from different economic perspectives: Or Neoclassical, Structuralist and Evolutionary theories revisited", a PhD-project on the implications of evolutionary economics for technology policy seemed a natural way to go. Or so I thought.
At Roskilde during participation in the PhD-program in Technology Policy, Innovation and Socio-Economic Development, I was exposed to several other Science and Technology Studies (STS) research traditions besides the economic one.
It was here, in the end of 1992, beginning of 1993 that I started to rephrase the initial research question for two related reasons:

- Firstly, I found out that many theoretical schools were interlinked, and it became impossible to demarcate the different approaches so neatly as to be able to compare their respective "outcome/implications" for technology policy.

- Secondly, it appeared 'prejudiced behaviour' to from the start delimit the problem setting to the economics domain only, in light of the relevance of the different types of STS and innovation theories I was exposed to[10].

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[9]The Maastricht Economic Research Institute on Innovation and Technology. At MERIT I attended the Postgraduate MA-Programme on Technology Policy and Innovation Management, which exposed me to most of the 'major players' in the neo-Schumpeterian/evolutionary economic research world.
[10]It may be interesting to note that I believe that founder and Director of MERIT, Luc Soete most probably would agree with this, as I remember him saying at the opening of the MA Programme that the E of MERIT **still** stood for economic, but that this may change into for instance environmental in the future.

Consequently, I started to turn the research question around and instead of asking what the implications of the new theory are to address the following research question:

> **What should a theory that can explain and guide real-life contemporary innovation and technology policy (ITP) look like ?**

The 'answer' to this question is what this dissertation is all about. The strategy chosen is to provide a synthesis of several theories that in my view add up and provide a useful 'focusing device' in guiding/explaining ITP. The relevance of this theoretical framework is then illustrated by discussing a recent Danish ITP analysis exercise, which can be attributed to have worked according to theoretical approach which is put forward in this project. The fact that this Danish exercise matches my theory is of course no coincidence. Thus, after I was exposed to this Resource Area Analysis in the beginning of 1993, it strongly influenced the way I thought ITP theory should look like, and the development of the theory and understanding of the Danish case took place simultaneously. In that sense, the methodology of the project is similar to the one adopted in an Israeli project that studied the biomedical electronics industry in that

> *The research is ... a combination of both empirical and theoretical research: there is no formal-theoretical model to determine from the outset the nature of the empirical test. The empirical and theoretical aspects continuously influence each other and are both outputs of the project. (Teubal, 1976, p.354)*

In my view this procedure is perfectly sound scientific practice, and in fact represents what most (if not all) scientists do in reality. This methodology differs from the positivistic economic one, as advocated by Friedman (1953), where 'correct predictions', which are independent of the theoretical framework, should assess the validity of the theory. This approach is in my view invalid since

> *...no observation can be independent of the conceptual framework, language and theoretical system of the observer.....Any observation requires both selection and interpretation. Empirical work involves the search for a mass of information which cannot all be addressed by the theory....the questions that are asked and the interpretations placed upon the analysis are inevitably coloured by the preconceptions, past experiences and anticipations of the observer [and as such] there is no objective, a theoretical yardstick with which the 'distance' of a theoretical model from the real world can be measured. (Hodgson, 1988, pp35-37)*

Adopting this world-view, basically boils down to instrumentalism, an approach in which theories are regarded as *nothing more* than instruments (Hodgson, 1988, p.33). Upon this interpretation a theory could be judged by its applicability in practice or any other goal the researcher sets out that the instrument should be able to 'add value to'. Now Machlup has stated that

> *Some purists among the economists have argued that they, qua economists, cannot give advice or make policy recommendations; that those who recommend or prescribe do so in their capacity as citizens or politicians. Such restrictive definitions of economics may be good for their ego but will not help their public image.*
> *For, regrettably, it is only in their roles as experts, forecasters, consultants, and policy advisers that economists are known to the public.(Machlup, 1978, p.389)*

Since I disagree with Machlup in that it is regrettable that the economist only is known to the public in his role as adviser, and believe it is in this very role that he adds value to society, this instrumentalist approach is the one adopted in this study.

1.2 The form of the dissertation, and *my contribution to science*

At least within the social sciences, the form of this thesis is untypical in that it consists of three articles, and a longer/broader paper that puts these in perspective. In my view, this strategy is preferable over the more traditional '200-page-dissertation'. This firstly, since I regard the PhD-project as the beginning of the academic career, and not as the end-result. And since writing articles/publishing is an essential part of academic work, I believe one cannot start too early getting engaged in this activity. Secondly, the refereeing system associated with publishing, ensures feedback on one's ideas from people that have no familiarity with either you or your project. This contributes much to the need of formulating oneself clearly and provides useful critical 'un-biased' feedback. Last but not least, this form of thesis-writing allows me to tell several inter-related stories in a more concise and focused form than the '200-page-dissertation' would have allowed me to.

It may be pretentious to speak about my contribution to science, but as I see it this is precisely what is required in PhD-work. Thus while still being a student in the formal sense, the PhD candidate is expected to contribute something to his/her discipline which enriches this in a certain aspect. This may be in the form of empirical work, and does not necessarily involve the generation of new theory.

In my case however, emphasis has been placed on the theory-generation by synthesising existing theories. There are four main theoretical components that are brought together in this synthesis:

- Economics of innovation/technological change
- Innovation and technology policy theory
- Strategic management theory: the resource-based view of the firm
- Constructive Technology Assessment

In my view the emerging 'resource-based approach to innovation and technology policy' (RBA to ITP), is a useful framework for explaining/ guiding real-life policy formulation and/or implementation.
The instrumentalist approach prescribes the usefulness of the synthesis as a measure of its validity/success, which is why the recent Danish ITP analysis exercise, is brought into the study[11]. In my view, this RBA to ITP is a useful framework, although surely still wanting further refinement and development. If however my dissertation/articles would bring about some more discussion of firm strategy, technology assessment, economics of innovation and ITP analysis as inter-related fields, I believe my contribution to science may in the long run prove very useful[12].

[11]Thus I agree with Arundel and Soete (1993, p.26) a good theory to guide policy should "be operational, i.e. the policies can be developed, implemented and managed within the existing structure of government".

[12]Contrary to what the uniformed reader may believe, even economics and strategic management science have been almost entirely free of cross-fertilisation, and have not had many similar items on their research agendas. This is described in a very humorous manner in an article called "An economist takes tea with a management guru" (The Economist, 1992).

1.3 The study's main outcome, and units of analysis: linking micro and macro

If one were to force me to in one line summarise the main outcome of this thesis it would be:

> **Innovation is a complex/systemic process, and in order to address it and the policies aimed at promoting/steering it, we need an equally broad, multi-disciplinary framework which ranges from micro- to macro-levels of analysis.**

What this implies is that the project's unit(s) of analysis are several. Thus, micro-level analysis of firm strategy is placed within its wider (regional, industrial) context, which in turn is put within the framework of the National System of Innovation (NSI). The level of analysis should of course be determined by the research question, and in my view one of the central claims of this thesis is that the research question cannot be 'answered' without adopting a systemic framework in which several levels of analysis co-exist. The multi-disciplinary, micro-to macro approach adopted in this paper has one major disadvantage. This is the lack of analytical precision and degree of formality, which lend neoclassical economic analysis such a high degree of simplicity in its normative recommendations. While I do believe policymakers need simple recommendations, I agree with Bo Carlsson in that

> *..we sometimes give precise answers to irrelevant questions, while it may be better to give vaguely correct answers to relevant questions (Carlsson, 1989, p.15)*

In particular since the aim of this study is to generate descriptive theory (see 1.1), and end up by suggesting the relevant questions, the advantages of adopting the multi-disciplinary, micro-to macro approach in my view outweigh this disadvantage. In doing so, we may avoid misguiding policymakers and not lead them "to ask the questions we can answer rather than those that are relevant or most important.(Carlsson, 1989, p.15)". The tendency of more traditional economics and its methodology to do precisely that, has been suggested, perhaps in its strongest form by Nobel Laureate W. Leontieff, who stated that

> *Page after page of professional economic journals are filled with mathematical formulas leading the reader from sets of more or less plausible but entirely arbitrary assumptions to precisely stated but irrelevant theoretical conclusions" (Leontieff,1982)*

1.4 How the empirical material was handled

As I argued above, this dissertation represents an attempt at generating a descriptive theoretical synthesis, the relevance of which is then illustrated by 'a case'. In this sense the use of empirical material comes closest to what Yin (1984) calls the Exploratory Case Study. According to Yin these type of studies, although naturally having some initial rationale and direction, are rather open-ended and instead of propositions these type of studies may rather be defined by a statement of purpose. This in my view fits with the approach described above where both empirical and theoretical aspects are considered outputs of the project, after continuously influencing each other during the research process. This process has meant, that my approach to the empirical material dealt with on the Danish Resource Area Analysis, has been an open-ended one as well, where I chose not to draw a clear line between theoretical development and the case material. Rather than setting up structured interviews, or conducting surveys, I chose to collect data through

- reading all official documents, where the RAA was explained and/or used
- reading newspapers, and articles in the 'business-press' about the analysis
- speaking to some well-informed sources within the organisations responsible for the RAA
- attending seminars, conferences of relevance to the RAA.

Now this approach may be criticised for adopting a 'snowball-methodology' of reading/attending that which seems interesting/relevant from the perspective of what one learns along the way. However in my view, the approach followed in the thesis is not only sound, but also the only way to ensure that the researcher can keep a somewhat open mind towards both theory **and** the empirical data. Now, in the epilogue to their classic "The discovery of grounded theory" (1967), Glaser and Strauss they point out that they differ from Merton in that in his view "data should fit the theory, in contrast to our position that the theory should fit the data (p.261)"[13]. In my view, as should be clear from the above, neither data nor theory can be treated as independent from each other as the researcher always will bring his theoretical baggage to the attendance of the data, and the empirical knowledge when regarding theory. As such, the theory should fit the data, **and** the data should fit the theory. This, in my view can only be achieved by adopting the open-ended unstructured approach to 'the case' as done in this study.

[13]The main disagreement between Merton and Glaser and Strauss in as to the usefulness of qualitative research which Merton dismisses, while Glaser and Strauss throughout the book try to outline strategies for such qualitative research.

Here I should also emphasise again that in attempting to develop descriptive theory, the aim of the thesis is to raise the relevant issues, rather than answer predetermined questions. Or, in Yin's terminology, there were no propositions to 'test' in a structured case study, rather the purpose of attending the case was to illustrate the theory that was being developed drawing in part on inspiration from attending this very case.

1.5 The way this dissertation will proceed

The chapters in this thesis will look as follows:
In **Chapter 2**, the relationships between economics, technology and innovation are analysed, and the stage is set for the systemic, evolutionary/neo-Schumpeterian approach that is an important part of the theoretical synthesis developed in this PhD-project.

In **Chapter 3**, innovation and technology policy (ITP) is looked into.

In **Chapter 4**, the resource-based view of strategic management is discussed, which also is an important part of the theoretical synthesis developed in this PhD-project.

After Chapter 4, the first article **"Linking Firm Strategy and Government Action: towards a resource-based perspective on innovation and technology policy"** follows, which was published in *Technology in Society*, Vol.17, No.4, 1995.

In **Chapter 5**, the above article is briefly placed in perspective, although the aim is not 'to write an article about the article'.

Hereafter, the second article follows, called **"Problems and prospects of bottom-up policy formulation: towards User Defined Innovation and Technology Policy (UDITP) ?"**. This article is forthcoming in *Science and Public Policy*'s August's edition.

In **Chapter 6**, the above article is briefly placed in perspective.

Hereafter, the third article **"Looking at medical technology assessment through innovation eyeglasses"** , is presented.

In **Chapter 7**, the above article is briefly placed in perspective.

Finally, **Chapter 8**, briefly concludes the dissertation and suggests items for future research.

2

Economics and Technology

2.1 Economics and The Black Box called Technology

> One of the continuing paradoxes in economic theory has been the contrast between the general consensus that technical change is the most important source of dynamism in capitalist economies and its relative neglect in most mainstream literature. Those economists, such as Marx in the nineteenth century and Schumpeter in the twentieth, who attempted to assign a more central role to technical innovation, were regarded as rogue elephants whose work, although certainly of interest, should not be taken too seriously.
>
> C.Freeman (1994, p.463)

The realisation that a large part of economic growth could not be explained by the growth in the quantity of resource inputs *per se*, but instead should be attributed to the *residual* in the models - the increased efficiency of those inputs - was devastating for economists (Metcalfe, 1987). In particular the theoretical model developed by Nobel Prize Laureate Robert M. Solow in 1956/57 (Solow,1956;1957) which showed that around 87,5% of the growth in output per worker in the USA between 1909-1949 was explained by this residual - coined technical change - had a major impact.
Thus technical change, a factor exogenous to this neoclassical growth model of Solow, which dropped on the economy like *manna from heaven*, suddenly was seen as the main contributor to economic growth.
Until the mid-80s growth accounting strongly inspired by the work of Solow[14] remained the dominant tradition in the economics of growth and technical change, since the efforts in studying

[14]Others like Abramovitz, Denison and Kendrick should also be mentioned here. See Abramovitz (1956), Denison (1962) and Kendrick (1973). Furthermore the Post- and Neo-Keynesian traditions should be mentioned where in particular Kaldor contributed notably with *Verdoorn's Law* which

technological diffusion, the interrelation of technical change and market structure, and the economics of innovation,....remained for the most part separate areas of study largely unconnected with the broader concerns of macroeconomics and growth theory (Silverberg and Soete, 1994,p.1) .

Since the mid-80s however, the situation has changed, and two types of theoretical developments redefined growth theory as we know it:

- One development where the basic neoclassical model is refined to incorporate endogenous technical change by distinguishing "between appropriable and non-appropriable effects in the production of innovation[15]"; so-called new growth theory[16].

- The development of an evolutionary approach to economic growth, i.e. the abandonment of the neoclassical heritage and attempt to build a superior analytical framework based on fundamentally different assumptions

While Thorstein Veblen, the father of institutional economics, already in 1898 had asked why economics was not an evolutionary science (Veblen 1898), and Schumpeter had laid the foundations for an evolutionary approach in the first half of the 20th century, it was only in the mid-80s that the approach really took off.
Suddenly, after having been around in the background since classical economics[17], the evolutionary economic tradition grew into more than just fragmented efforts. While it goes beyond the scope of this dissertation to establish why evolutionary economics rose precisely in this period, one major reason for this is the simple fact that it was possible[18]! Modern computer power, the refinement of evolutionary thinking in the biological and social sciences, combined with developments within the mathematics of non-linear systems and chaos theory all contributed to the increased feasibility of evolutionary modelling.

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claims "a positive relation between economic growth and productivity, with causality going from the first to the latter" (Verspagen, 1992, p.22).

[15]Verspagen, B., Uneven Growth between Interdependent Economies: An Evolutionary View on Technology Gaps, Trade and Growth, University of Limburg, MERIT, Dissertation 92-10.

[16]The most well-known proponents of new growth theory are: Philippe Aghion, Gene Grossman, Elhanan Helpman, Peter Howitt, Paul Romer and 1995 Nobel Prize Laureate Robert Lucas. For some contributions in the area see Foray and Freeman (1993).

[17]For an overview on the evolution of evolutionary theories in economics, see Clark and Juma (1988).

[18]For an interesting discussion on the "crowding out" of evolutionary perspectives in economics see Andersen (1993). For a discussion on the history/development of neoclassical growth theory and how this relates to evolutionary economics, see Nelson (1994).

This combined with the appearance of An Evolutionary Theory of Economic Change by Nelson & Winter in 1982, paved the way for the embarkment of the evolutionary, neo-Schumpeterian approach. This book showed that evolutionary modelling indeed was feasible, while also arguing convincingly for the need and importance of a fresh new start[19].
The evolutionary approach, and the renewed interest in Schumpeter under the heading the neo-Schumpeterian approach have come to mean almost one and the same thing. Thus Nelson and Winter stated that

> *the term "neo-Schumpeterian" would be as appropriate a designation for our entire approach as "evolutionary." More precisely, it could reasonably be said that we are evolutionary theorists for the sake of being neo-Schumpeterians-that is, because evolutionary ideas provide a workable approach to the problem of elaborating and formalizing the Schumpeterian view of capitalism as an engine of progressive change (Nelson and Winter, 1982, p.39)*

It is important to note though that some see this equation of evolutionary and (neo-) Schumpeterian approaches as mistaken, and even misleading. Thus Hodgson in an excellent book in which the history of evolutionary thinking in economic theory is portrayed in considerable detail, writes

> *In conclusion, the invocation of Schumpeter's name by the new wave of evolutionary theorists in the 1980s and 1990s is both misleading and mistaken. Note for instance the evolutionary modelling of Iwai (1984a,1984b), Nelson and Winter (1982), Rahmeyer (1989), Silverberg (1988) and Silverberg et al. (1988). These authors make repeated claims that their work is in a 'Schumpeterian' or 'neo-Schumpeterian' mould. There are superficial similarities, such as an emphasis in common with Schumpeter on invention and innovation, and perhaps even imitation. But at a deeper theoretical level there is a complete divergence.*

[19]Kenneth Boulding already in 1981 published a "textbook" on evolutionary economics, which however is rather different in approach from the material discussed here. For a very easily accessible first introduction to the field though see Boulding (1981).

In contrast to Schumpeter, the work of the new evolutionary modellers is based on a 'natural selection' analogy, of a Darwinian or of a Lamarckian kind....Yet as shown above, Schumpeter eschewed the natural selection analogy for economics and adopted an entirely different conception of evolution in social science. If there is an implicit 'natural selection' analogy in Schumpeter's writings, in the process of competition for instance, then it enters only by the backdoor. It is contrary to Schumpeter's explicit intention....
Schumpeter's name is also widely invoked not only as the spiritual symbol of selectionist evolutionary modelling in economics, but also as the father of a theoretical school addressing technological change, despite the fact that he had very little to say about the latter in his work. Indeed as Heertje (1988, p.82) concludes, 'technical change, in the strict sense of the development of new technical knowledge and possibilities, and the diffusion of knowledge are almost wholly absent from his exposition (Hodgson, 1993, pp149-150).

While this is an interesting point of view, for the purpose of this thesis, I will treat neo-Schumpeterian and evolutionary economics as meaning the same thing.
In doing so, I use both terms in a broad sense, indicating the research focus and subject matter rather than a precise clear-cut definition or ideological standpoint[20].
Now, the aim of the thesis is to establish and inquire into the why and how of ITP from an economic and managerial perspective, and delimitations have been drawn accordingly. The (neo-)Schumpeterian perspective, in the above sense, lends itself particularly well for this issue, as will become throughout this chapter and thesis. As Lundvall (1992) has argued, one may interpret social science theories as 'focusing devices', where focusing on some aspects of the 'real world', necessarily implies not dealing with other matters.
In light of our research aim, it makes good sense to pick the neo-Schumpeterian focusing device, which Sundbo classifies as the *economic innovation theory* paradigm[21].

[20]Thus evolution should be understood in a metaphorical sense, and no claim as to isomorphism between biological and economic theories is claimed here, see (Dosi and Nelson, 1994)
[21]It may be more appropriate to call it technology-economic paradigm, which would fit better with the Danish concept adopted in Sundbo's PhD dissertation - teknologi-økonomi, See Sundbo (1994). Henceforth, I will therefore use the term technology-economic paradigm.

This paradigm was 'born', with the publication of the book Technical Change and Economic Theory in 1988 (Dosi et al, 1988)[22].
This book, sometimes referred to as *The Bible* at Roskilde[23], combined with research in the framework of the OECD's Technology/Economy Programme (TEP)[24] has firmly and rapidly established this research tradition within economics, turning it into a 'mature area of economics' that can be considered to stand alongside other core economics areas (Stoneman, 1995).
According to Sundbo (1991), the main focus in the approach, is how to explain innovation as a source of economic growth, further suggesting that this line of research tends towards technological reductionism/determinism. Thus both economic evolution and industrial development, according to Sundbo, are interpreted through 'technology-eyes', i.e. it is technology that serves as the frame of reference. He receives support in this view, from Hughes who in a book review of Dosi et al (1988) writes that

> *The main result of this belief in the pre-eminent importance of technical change is a strong tendency towards technological determinism....[and]*
> *Ironically, the complaint of the technology school has long been that neoclassical economics ignores technical change through treating it as exogenous and as a black box. Yet here they are tending to treat the economy as a black box, and consequently technology remains exogenous (Hughes, 1991, pp122-123)*

Still, to me these claims seem somewhat un-nuanced, as it appears that a great deal of evolutionary economists increasingly regard technological change as what attracted them to the evolutionary school, but increasingly view innovation in a broader sense as underlying economic growth.
Still, during the writing of this thesis, it became clear to me that my approach would benefit by linking up to the emerging *strategic paradigm*, which according to Sundbo is the theoretical synthesis of the technology-economic and entrepreneurship traditions/paradigms[25], and which regards strategic action in a dynamic evolving environment as central to innovation analysis.

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[22]The book has a "sequence" in Foray and Freeman (1993), a book that contains a selection of papers presented to the OECD TEP Conference on "Technology and Competitiveness" in Paris, June 1990.
[23]This in particular during our *innovations forums* (interactive ongoing research seminars addressing methodological issues in relation to PhD dissertation writing) in 1992 in the framework of the PhD Program in Technology Policy, Innovation and Socio-Economic Development.
[24]See OECD (1991;1991;1992).
[25]Entrepreneurship theory has according to Sundbo two main explanations of the act of Entrepreneurship: the personality theory, and the role theory. While "the economic innovation theory ends up in technological reductionism, the entrepreneurship tradition has tendencies to psychological determinism" (Sundbo, 1991, p.163).

In this strategic approach, innovation ought to be seen from the point of view of the single firm, which in turn should be understood as being part of the larger context that surrounds it (Sundbo,1991)[26].
While I agree with the technology-economic paradigm that the macro-level motivational force for innovation is/should be economic growth, it is not my intention to contribute to growth theory per se.
Thus issues such as income distribution, the link between economic growth and development, technological change and (un)employment, technological change and the environment, are important but beyond the scope of this project[27].
As will have become clear and will be further developed throughout the thesis, rather an attempt is made to link the technology-economics and strategic paradigms in innovation theory in order to come up with a theory that links micro and macro, and is operational in the real world[28], while theoretically consistent. Now then, let us start by discussing the first building block of this theory evolutionary/neo-Schumpeterian economics.

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[26]As we shall see below, this approach fits well with the so-called 'systems perspective'.

[27]For an excellent treatment of technological change and unemployment see Freeman,Clark and Soete (1982). For a more philosophical debate on issue of fairness and income distribution see Rawls (1972), For the link between technical change and the environment Kemp and Soete (1992).

[28]Although it is not the aim to develop a theory that political scientists would consider workable ! (see introduction).

2.2 Opening The Black Box called Technology: Prospects and Problems

> Technical change, in the strict sense of the development of new technical knowledge and possibilities, and the diffusion of knowledge are almost wholly absent from his [Schumpeter's] exposition.
>
> A.Heertje (1988, p.82)

> Joseph Schumpeter (1883-1950) is the most influential single writer on technical change.
>
> J. Elster (1983, p.112)

The economics of innovation and technological change as a research paradigm has grown as rapidly as it did, by attracting an increasing number of scholars who were dissatisfied with the focusing device that mainstream economics provided. Thus, in the preface to Dosi et al 1988, it reads

> *This book emerged out of the growing dissatisfaction felt by a number of economists and non-economists alike with the way technical change has been and continues to be treated in mainstream economics. Each one of us, in his own way, had been involved in critical assessments of the way orthodox economic theory deals with 'change'. Each one of us, had come to the conclusion that any analysis of change which ignored the fundamental role and special character of technical change, even in the very short run, could not be valid. The time seemed ripe to bring together in a coherent framework a number of authors working in related directions to formulate a systematic critique of orthodox economic theory and to sketch out the common elements of a first, alternative theory on the role of technical change in microeconomic behaviour, processes of structural change and macroeconomic transformation of the economic system. This book presents such a first attempt. (Dosi et al, 1988, preface)*

Now it is important to highlight two elements of the above citation; firstly the aim is to formulate a systematic critique of mainstream economics, and secondly the intention is to outline the initial contours of an alternative approach. It must be said that until now the neo-Schumpeterian/evolutionary economic approach has been more successful in fulfilling the former aim than the second.

To be fair, it must be stated that the editors of Dosi et al were aware of this, and stressed this point in the introduction to the book. Without dwelling on this issue, it must be stressed that it is still difficult to treat the by now immense body of research within the evolutionary tradition, as homogeneous, and the researchers belonging to the paradigm have a less clear-cut shared conceptual foundation than mainstream economics. Or, as Saviotti and Metcalfe put it

> *At this state of development of an evolutionary approach it is much easier to identify the reasons for the resurgence of interest in it than to define accurately what constitutes an evolutionary approach. (Saviotti and Metcalfe, 1991, p.2)*

This is mostly due to the fact that the definition and understanding of the terms 'evolutionary' and 'neo-Schumpeterian' is still an open-ended contest with a wide range of possibilities (Saviotti and Metcalfe,1991). Therefore, it is crucial to specify which elements of the wealth of available "self-named" evolutionary/neo-Schumpeterian claims I adopt and use in this thesis. This will be attempted in the next section, but the complexity of the task should not be underestimated. Thus, besides the issues of boundaries/differences between and accuracy of terminology of evolutionary and neo-Schumpeterian approaches there is another element complicating a fair and sober presentation of the approach.
This, since the fact that it has so far been easier to criticise the neoclassical enterprise than to present a coherent alternative framework to it, has led to the emergence of a school which tends to communicate mostly with itself rather than with the mainstream. Heertje, in an excellent paper assessing the pros and cons of the neo-Schumpeterian approach to economics, makes this point (in my view too) forcefully when he states that

> *Neo-Schumpeterians have a tendency to consider themselves as a group or a school, sharing common views and opposing in particular, the so-called neoclassical scheme. Well-known representatives, such as Nelson, Winter, Freeman, Dosi, Rosenberg and Soete, refer to each other's work, of which they have a priori a higher opinion than research carried out by scholars outside the group. (Heertje, 1994, p.267)*[29]

In particular Heertje argues, that the lack of theoretical sophistication has led to "the fact" that neo-Schumpeterians have been the ones asking the right questions while 'the rest of the profession' has provided the answers.

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[29]Heertje (1994, p.267).

Heertje goes too far in my view in his portrayal of the neo-Schumpeterians as being engaged in a kind of collective effort to at any cost overthrow the neoclassical 'common enemy'. Thus, he both seems to underestimate the theoretical finesse of some neo-Schumpeterian work, while overestimating the success of finding "the neoclassical preliminary answers". Still, to a large extent his criticism is justified, and we will keep it in mind in the rest of this thesis[30].

This leaves us with the problem that we have to define an emerging approach of which the definition of is open to discussion, that draws its strength more from profound and thorough criticism of the mainstream approach than presenting an alternative to it, and which has created a language and scientific paradigm of its own. Since I started my education in neoclassical economics, and slowly drifted into the techno-economic neo-Schumpeterian approach, and have met/listened to all of the people Heertje considers as well-known representatives and many more, it is in my view still possible for me to present a balanced picture of the approach.

In particular this is so, since as we shall see in later chapters I have drifted somewhat from this technology-economics approach towards a strategic approach[31].

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[30]Although this thesis is more of an attempt to 'start' a dialogue between strategic management theorists and neo-Schumpeterians than the encouragement of an internal economics debate/communication per se. About Heertje it should be noted that I criticise his views as expressed in the article not his insight into the neo-Schumpeterian debate, as I am well aware he has been president of the Schumpeter Society.

[31]Looking back at my period when I attended the Postgraduate MA Programme in Technology Policy and the Management of Innovation at MERIT, certainly at that stage I was 'part of' the technology-economics tradition while slowly moving towards the strategic views during my stay at the RUC PhD-program.!! This allows me to provide both an inside-out and outside-in view on the neo-Schumpeterian paradigm.

2.3 Neo-Schumpeterian/Evolutionary theory

> ..technical change offers a challenge to analysis in that it is fundamentally unpredictable. 'If I knew where jazz was going, I'd be there already', Humphrey Lyttelton is reported to have said. Similarly, any attempt to explain technical change sooner or later comes up against the paradox of turning creativity into a dependent variable.
>
> J. Elster (1983, p.9)

I don't remember who said it, but it was probably a famous person who stated that the only thing that always stays constant is change.
If one is forced to single out one central item of the neo-Schumpeterian/ evolutionary approach it is precisely that qualitative change is essential to long-term economic development. One may disagree whether the changes are revolutionary or evolutionary, and in fact some argue that Schumpeter's insistence on more radical, revolutionary changes as sources of dynamism disqualify him as an evolutionary economist (Magnusson,1994). However, it is beyond doubt that the central focus of the approach is change. As we have seen in section 2.1., of the changes taking place in economic life, technical change is regarded as the most central in the neo-Schumpeterian approach[32]. Schumpeter, divided technological change into the three stages of: invention, innovation and diffusion. While invention represents the generation of new ideas, innovation is the commercialisation of these and diffusion about the spreading of these across (potential) markets. Two important things should be noted. Firstly, by now innovation as a concept is often used as a term that simply describes doing something new/different, rather than the stage that Schumpeter identified (Stoneman, 1995)[33].
I will use innovation in this sense where it represents a commercial application of a new product, process or service. These innovations may be local or global, depending on the question at hand. Thus, a new production process may be an innovation for a firm without representing an innovation on a regional level if another firm in the region already employs this method. Furthermore innovations may differ in their degree of radicality.

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[32]For an excellent discussion of the differences between practice, technique, technology and technical and technological change see Elster (1983,pp.91-95).
[33]It is interesting to note that in Dosi et al 1988 in the index under innovation it simply reads see technical change!! Dosi et al (1988, p.640)

Freeman & Perez (1988) have made a very useful taxonomy of innovations separating between[34]

incremental innovations - which are continuous small changes often resulting from learning by doing/using rather than deliberate effort

radical innovations - which are discontinuous events typically as a result of R&D

Changes of 'technology system' - which affect several branches of the economy as well as give rise to entirely new sectors, and are based on a combination of radical and incremental innovations, together with organisational and managerial innovations affecting more than one or a few firms

Changes in 'techno-economic' paradigm (technological revolutions) - which have a major impact on the entire economy, and carries with it many radical and incremental innovations and may eventually embody a number of new technology systems[35].

Thus, the separation between the three activities as different stages is today seen as of limited relevance, where instead technological change/innovation are seen as a continuous process. On a similar note, the linear model of science, where R&D (discovery) leads to production which is followed by marketing, has been replaced by interactive models where feedback loops between and interaction are allowed for (Kline and Rosenberg, 1986)[36]. Secondly, note the term service in the definition of innovation. While the area of innovation in services is still in its research infancy, in my view it is crucial to include this aspect especially in light of the ever-increasing share of economic activity services seem to occupy.

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[34]Freeman and Perez, (1988, pp.45-47). Pavitt (1984) has made a widely used taxonomy of industrial sectors dividing them into supplier-dominated, production-intensive and science-based which differ in terms of relationship to external sources of knowledge, in-house scientific and technical activities, diversification, industrial structure and skill formation. Recently this taxonomy has been criticised/elaborated Frøslev Christensen (1995), where he links up to the resource-based theory of the firm which will play a key role in this thesis. Furthermore one cannot mention technological paradigms without referring to the article by Dosi (1982) which together with Sahal (1985) laid the foundations for 'paradigmatic thinking' in the economics of technical change/innovation.

[35]These meta-paradigm changes, are seen as causing Long Waves - the so-called Kondratiev cycles - by Freeman and Perez. Thus the changes in technological practice require parallel institutional & organisational changes which they claim will typically require time to adjust leading to mismatches and cyclical behaviour. Also see Perez (1983;1985).

[36]Their "chain-linked" innovation model is probably the most influential model of this kind, widely used in particular on OECD circles.

So far however it is undeniably the case that innovation theory has neglected this increasingly important area.
Once we view innovation in the above way it is possible to present some stylised facts as done by Dosi, who together with Nelson and Metcalfe, must be regarded as today's gurus of evolutionary economics. Dosi submits the following five stylised facts on innovation (Dosi, 1988, p.222-223):

> *1.Innovation involves a fundamental element of uncertainty, which is not simply a lack of all the relevant information about the occurrence of known events but, more fundamentally entails also (a) the existence of techno-economic problems whose solutions procedures are unknown.., and (b) the impossibility of precisely tracing consequences to actions*
>
> *2.The increasing reliance of major new technological opportunities on advances in scientific knowledge*
>
> *3.The increasing complexity of research and innovative activities militates in favour of formal organisations...as opposed to individual innovators as the most conducive environment to the production of innovations. Moreover, the formal research activities in the business sector tends to be integrated within more or less integrated manufacturing firms*
>
> *4.A significant amount of innovations and improvements are originated through 'learning-by-doing' and 'learning-by-using'*
>
> *5.Technical change is a cumulative activity.*

These stylised facts mark an opposition to the neoclassical tradition, and together result in the need for a behavioural theory of the firm. Thus since this fundamental uncertainty exists, rationality in the neo-Schumpeterian world can only be bounded in the sense as developed by Nobel Laureate Herbert Simon. He has argued, that real-life rationality differed from the 'perfect' one assumed in neoclassical theory, since neither their knowledge, nor calculation powers allowed them to perform the optimisation of means to ends as assumed in this theory (Simon, 1992). Consequently, firms can no longer optimise and maximise profits, but rather are engaged in satisficing and profit-seeking. Since firms will apply rules of thumb in decision-making rather than fully rational models, they will differ and we no longer can speak about the representative firm.

Finally, since technological change is cumulative today's and tomorrow's options depend partly on yesterday's choices i.e. history matters (see Verspagen, 1992). The ability of a firm in this world view depends on its ability to adapt - learn - to ever-changing circumstances.
The neo-Schumpeterian capitalist world then consists of heterogeneous firms that compete with one another on the basis of innovations, which create an ongoing evolutionary turmoil through the process of *creative destruction.*[37].
So far, we have identified two of the core qualities a theory should posses in order to be coined neo-Schumpeterian/evolutionary

- The analysis should be explicitly dynamic;

- The analysis should include cumulative processes

These need to be complemented by a third factor, in order to fully qualify as evolutionary theory (Dosi and Nelson, 1994; Metcalfe, 1994)

- The analysis should explain economic behaviour as a result of two opposing forces:

  I. Those forces, involving a random element, that create variety and
  II. Those that select which of the various behaviours will survive[38]

While in a strict sense these conditions may need to be fulfilled to qualify a theory as evolutionary, the identification of these forces is probably the most difficult aspect of evolutionary theorising. Much debate surrounds which is the appropriate unit of selection : the firm, industry, nation ? Also, matters are complicated in that in the economic world, in contrast to its biological counterpart, the generation of variety is (partly) purposeful.

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[37]According to Schumpeter, "entrepreneurial actions constitute the engine of economic progress, and lead economies into the alternating periods of prosperity and recession. Prosperity represents the positive side of economic progress, when innovative investments are undertaken which make the economy boom, whereas recession represents the 'negative' side. The gales of ' creative destruction', through which 'old' firms disappear and are replaced by firms embodying new productions functions, predominate in the latter." (Brouwer,1991, p.2).

[38]Alternatively one may say that "...evolution means two things: the gradual unfolding of phenomena in a cumulative and thus path dependent way; and, quite separately, a dynamics of system behaviour which creates change and emerging structure from variety in behaviour (Metcalfe,1995, p.28). The broadest definition I have seen is in Dosi (1991, p.354) where he considers "'evolutionary theories' a rather heterogeneous group of modelling efforts which share the emphasis on the dynamic properties of economies characterised by repeated emergence of various forms of innovation, decentralised processes of discovery and historical persistence of particular studies of change."

Thus firms are engaged, for instance through R&D, in purposeful search processes, which though are *local* in the sense that where they search today is partly determined by what they explored yesterday[39].
Since also firms and institutions co-evolve (Nelson,1994); changing in one imply changes in the other, further difficulty arises in singling out appropriate variety-generating forces and selection mechanisms.
One may get the impression here that in the evolutionary world firms are nearly helpless in dealing with all this complexity surrounding them. Here however, the central concept of routines comes in. Nelson and Winter (1982) have identified routines as the economic counterpart of genes in the biological world, i.e. heritable and selectable traits of the phenotype at hand; the firm[40]. For them routines

> *include characteristics of firms that range from well-specified technical routines for producing things, through procedures for firing and hiring, ordering new inventory, or stepping up production of items in high demand, to policies regarding investment research and development (R&D), and overseas investment.(Nelson and Winter, 1982, p.14)*

These routines, deliberately connote behaviour that is executed without too much deliberation, and typically involves habits or customs. As such, they typically involve a *tacit* - uncodifiable - component. Still since they are (partly) selected by the environment in the firm's quest for profit, they can be interpreted as the 'appropriate and effective' behaviours in the environments in which they are invoked (Nelson, 1995). While these routines form the backbone and corporate memory of the firm, in evolutionary economics they are also viewed as the potential source of demise when firms are in need of change. Thus it takes time and effort to change these routines when changes in the external requirement demand such. Especially, when some processes the firm is engaged in are irreversible (Dosi and Metcalfe, 1991), in terms of for instance financial commitment, path-dependent *outdated* routines may cause the demise of firm[41].

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[39]It may be worth pointing out here that this path-dependency is not equivalent to determinism. In particular since most evolutionary models adopt non-linear dynamic (chaos) models, in which infinitesimal changes in input may lead to considerable changes in reached output this is an often heard misinterpretation. For a short good overview of the importance of non-linear dynamics see Saviotti and Metcalfe, (1991).

[40]In biology genotype stands for "the genetic inheritance of living creatures.... [while] phenotypes [are] defined in terms of a set of variables that happen to be of interest to the analyst, but which include those that influence the "fitness" of each living creature....[where] phenotypic characteristics are presumed to be influenced by genotypic ones, but not uniquely determined by them" (Nelson, 1995, p.57).

[41] As we shall see below in the chapter on the resource-based view on the firm routines also in that theory play a crucial role, but there have a more positive connotation.

This 'negative' side of routines, referring to inertia and rigidity provides us with a natural link to the second major factor that helps firms to deal with uncertainty; the fact that firms are part of a larger innovation system. It is to this larger systems perspective that we turn in the next section.

2.4 The institutional context: an innovation systems perspective

> New tools and perspectives are becoming available which allow us to think of economies as evolving, emergent structures in which the creative activities of firms play a powerful role. But no firm acts in isolation; the wider institutional matrix is of vital importance to a clear understanding of innovation performance
>
> J.S.Metcalfe, (1994, pp.34-35)

As the above citation indicates the evolutionary perspective brings with the recognition that actors do not operate in isolation. The emphasis on context-specificity, learning, path-dependency and variety-generating/selection forces all point to the importance of the institutional set-up for firm-level innovation. Thus, a neo-Schumpeterian/evolutionary approach leads quite naturally to the assumptions that

> *...the most fundamental resource in the modern economy is knowledge and, accordingly, that the most important process is learning..... [and secondly that] learning is predominantly an interactive and, therefore, a socially embedded process which cannot be understood without taking into consideration its institutional and cultural context (Lundvall, 1991, p.1).*

While I do not at this stage want to enter another debate on the scientific boundaries of the evolutionary and now also the institutional economic approach, it should be noted that the two fields have influenced each other and will continue to do so.
As in the case of evolutionary economics, the institutional approach has been around for a long time, and has been developed mainly as a critique of the dominant neoclassical approach. Founding father here can be identified as Thorstein Veblen, who as already stated above in 1898 had asked why economics was not an evolutionary science. (Interestingly, I should perhaps note that as far as I know a neo-Veblian school has not yet been coined.)
While also in this approach it is difficult to pinpoint the core assumptions, W.J. Samuels has suggested eight principal facets of institutional economics as a body of knowledge. Two of these immediately show the close kinship to the evolutionary approach.
These are the insistence on the importance of social and economic evolution, and the emphasis on the importance of technology (Samuels, 1995).

As in the in the case of evolutionary economics again different definitions of institutions co-exist. Thus, Veblen defined them as habits of thought common to the generality of men, while Commons defined them as collective action in control and enlargement, or liberation or individual action[42].
Hodgson, one of the key people in attempting to link the institutional and evolutionary approaches, has defined a (social) institution as

> *a social organization which, through the operation of tradition, custom or legal constraint, tends to create durable and routinized patters of behaviour (Hodgson, 1988, p.10).*

When we combine this with the definition provided by Johnson in which

> *Institutions are sets of habits, routines, rules, norms and laws, which regulate the relations between people and shape human interaction. By reducing uncertainty and, thus, the amount of information needed for individual and collective action, institutions are fundamental building blocks in all societies. (Johnson, 1992, p.26)*

we can grasp the full meaning and relevance of institutions for our evolutionary approach. Thus, through the creation of routinised patterns of behaviour they reduce the uncertainty facing the innovating firm, and hence partly determine its search space. In other words, since in the evolutionary perspective firm success is determined to a large extent by its ability to learn and adapt to changing circumstances the institutional structure becomes an indispensable part of the analysis . Thus, since learning and searching take place in the 'search space' which is defined by the economy, innovation is an endogenous process moulded by the institutional set-up (Johnson, 1992).
As Johnson argues learning and searching are thus not 'unprejudiced', and may follow technological trajectories, and are influenced by the dominant techno-economic paradigm.
This 'paradigmatic' approach[43], developed mainly by Dosi (1982), Freeman and Perez (1988), emphasises that learning and searching typically will tend to be directed in certain ways conducive to and compatible with the existing institutional structures. What this systems view clearly does is to establish that firms can function even in the evolutionary world, where there is fundamental uncertainty and they are blessed with only bounded rationality.

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[42]See Samuels, 1995, p.575.
[43]For more on the approach see chapter 7.2.

Thus, the paradigms, trajectories or whatever we call them provide a focusing device for the firm where to search, and no radical changes in firm searching behaviour may be necessary unless a change in techno-economic paradigm shows itself (see 1.2).
In fact, we may say that 'the system' is a macro-version of what the routine is at the micro-level[44]. In the next section we look a bit closer at this mixture of levels of analysis which is an essential element of the evolutionary approach.

2.5 On the level of analysis: the single firm within the NSI

> In terms of economic evolution, design configurations are subjected to two distinct kinds of selection process: internal selection processes in business units and their umbrella firms to decide which configurations to adopt and how to develop these - the prerevelation stage - and external selection processes in which the market selects between competing artefacts - the post revelation stage. While this is straightforward enough, matters are necessarily made more complex by the fact that technologies are not developed by firms in isolation; rather they operate in the context of a wider innovation support system
>
> J.S. Metcalfe (1994, p.33)

As we have seen innovation does in the evolutionary approach take place in a wider institutional context, and economic agents can no longer be treated in the positivistic methodological individualist way.
In fact, it becomes crucial to address the relations between the various sub-systems relevant for innovation, and consequently a tricky jumping back and forth of level of analysis seems warranted. Keith Smith (1995) distinguishes between three main systems approaches: the technological systems approaches (Bijker et al,1987; Bijker and Law,1992), the industrial clusters approach (Porter,1990;Dahmén,1988) and finally the national system of innovation (NSI) approach (Lundvall,1992; Nelson,1993). While there is overlap, the NSI approach is the one most focused upon learning and is the one followed here. This choice of perspective, where an attempt is made to link firm level innovation analysis with treatment of the NSI, follows from the aim of this thesis; the development of ITP at a national level. In my view, it does despite tendencies to both regionalisation and globalisation still make good scientific sense to address this national ITP.

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[44]The analogue indeed is interesting in that both paradigms as well as routines may be enhancing to growth through the reduction of uncertainty, but can also work detrimental in that they may lead to inertia and hence block changes when necessary. Montgomery (1995), has argued that evolutionary theorists tend to focus on this 'inertia-aspect' while strategic management theorists tend to emphasise the positive side. For an interesting 'evolutionary' model that describes the 'paradigmatic changes' taking place in the life cycle of a technology/innovation at a firm-level see Abernathy and Utterback (1978).

As long as we realise that the NSI is an open system, and interacts with both regional and global institutions/actors, similarities in culture, language and geographical proximity must in my view be seen as demanding some form of national approach (Lundvall,1992; Nelson, 1993).
As is the case in nearly every social science concept several NSI definitions exist. Amongst these:

> *A national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and financial, inasmuch as the goal of the interaction is the development, protection, financing, or regulation of new science and technology (Niosi et al, 1993, p.212)*

and a 'more evolutionary' definition where

> *NSI may be defined as one of the forces which influence the behavioural rules and the search space which, in turn, is a partial determinant of the sequence of changes in the production and product routines of firms (Andersen, 1992, p.91)*

McKelvey (1991) has singled out and compared the four (Michael Porter, Chris Freeman, Bengt Åke Lundvall and Richard Nelson[45]) most central/well-known approaches to the study of NSIs. On the basis of a taxonomy of the four's different conceptions of technology and technical change, McKelvey comes to the following table that summarises the different views of/on the NSI:

[45]Note that of the four only Michael Porter cannot be considered a neo-Schumpeterian/evolutionary economist.

Table 2.1. What are national systems of innovation ?

Porter	Not possible to analyse general national differences, only specific, successful industries in a country. The national system refers to the environment supporting innovative activity in companies, i.e., competition in the home market, supporting industrial structure etc. *Empirical focus*: Comparison of industries.
Freeman	A new, radical technology promotes social and institutional innovation on a national scale. Otherwise innovation may be incremental and technological. *Empirical focus*: Comparisons of nations based on their innovations and adjustments in social institutions.
Lundvall	The national system refers to the national economy, but there is stress on the importance of linkages and on interaction within development blocks. The national system of innovation is formed by the relevant institutions and industrial structures. *Empirical focus*: The historical development of institutions and production structures in different countries.
Nelson	The national system refers to the national economy. Differences in industrial structure (such as the needs of industry for science and technology and whether technology is public or private) and differences in organization of institutions (especially the R&D system) explain how national systems of innovation differ. *Empirical focus*: Current institutional differences between nations[46].

Source: McKelvey, 1991, p.136

What should be clear is that no matter how the NSI is defined, the concept and its characteristics (e.g. irreversibility, path-dependency) is very compatible with evolutionary economic analysis.
Zysman (1994) has linked all the above institutional, evolutionary and NSI arguments to explain 'How institutions create historically rooted trajectories of growth'.

[46]An illustration of the fact that Mckelvey's interpretation of Nelson's view still holds can be found in the first chapter in Nelson (ed.), 1993, where Nelson and Rosenberg on page 3 write that: "This book is about national systems of technical innovation. The heart of the work consists of studies of 15 countries, including the large market-oriented industrialized ones, several smaller high-income countries, and a number of newly industrializing states. The studies have been carefully designed, developed, and written to illuminate the institutions and mechanisms supporting technical innovation in the various countries, the similarities and differences across countries and how these came to be, and to permit at least preliminary discussion of how the differences matter".

His argument is that

> *The particular historical course of each nation's development creates a political economy with a distinctive institutional structure for governing the markets of labor, land, capital and goods.*
> *That national institutional structure shapes the dynamics of the political economy and sets boundaries within which government policies are chosen. It acts as a parameter, creating a national political economy. (Zysman, 1994, p.279)*

According to Zysman this institutional structure, lays out the logic for the behaviour of the actors in the economy and the interaction between them. Convincingly he argues that NSI and evolutionary arguments need to be complemented by institutional analysis, especially since 'markets, embedded in political and social institutions, are the creation of government and politics'. Quite naturally it seems we are suddenly engaged in a debate on the role of policy. It is to the role of innovation and technology policy in particular that we now turn in the third chapter.

3

Innovation and Technology Policy (ITP)

3.1 ITP: Towards an alternative theory?

> If you can never bathe twice in the same river, how can you draw normative implications from past swims for future ones ?
>
> G.Dosi (1991, p.358)

The second chapter ended with the systems perspective on innovation, and this presents a natural link to this chapter on innovation and technology policy. Thus, while we may separate between policies which treat the innovation opportunities of firms as given, and those that try to expand the "set" of those possibilities[47]

> *to apply this dichotomy the policy maker must identify the relevant design configurations and judge the current possibilities for innovation within any given design configuration. The scope for technological improvement, the likely productivity of innovative effort, the significance of developments in the underpinning knowledge bases and their location in different institutions must be understood in some detail if policy is not to collapse into vague generalities. In short, a technology systems perspective is central to the effective pursuit of policy (Metcalfe, 1994, p.935).*

[47]Or "..the role of policy might be twofold. Either, it might stimulate the progress along the prevailing trajectories - and this is what industrial policies often end up doing - or it may take on the more demanding task of making it easier for agents to shift from one trajectory to another. Dalum, Johnson & Lundvall (1992, p.299).

However, the development of normative policy implications of the evolutionary enterprise is as implied by Dosi's comment with which this section started, far from an easy task. In particular Dosi (1991, p.358) mentions three reasons why "there is little hope of developing normative propositions of the elegance and generality that is found in standard microeconomics". These are:

- The complexity (impossibility) of developing criteria for optimality, due to 'eternal' emergence of unique and unexpected events.

- The problem that non-linear dynamic feedback mechanisms diminish the potential use of 'exhaustive lists of all possible events' even if these could be developed *ex ante*.

- There is no clear yardstick to compare different states/events against, to provide solid comparative ground.

Before we 'anyway' turn to an attempt at to outline the contours of ITP in an evolutionary setting, it is crucial to clarify what exactly it is we are speaking about.
First of all, when looking at the literature it seems as if it is fully legitimate to use the terms science policy, research policy, business policy, technology policy, industrial policy and finally innovation policy interchangeably. While a treatment of the differences between these goes beyond the scope of this paper it is thus crucial to define what I mean by ITP. I define ITP as policies that are intended to influence the decisions of firms, public agencies and enterprises to develop, commercialise or adopt new (technological) products, processes or services[48]. Thus a research policy which aims at generating commercial results is in this view (part of) an ITP. Also industrial policy which aims at improving competitiveness through the stimulation of innovation passes 'the test'. Not all policies pass this test however, and the crucial aspect is that 'something new' has to happen.
Furthermore it becomes at this stage crucial to state more precisely what is meant by technology. Many definitions co-exist, which is particularly unfortunate for a concept like technology of which every-one already has his daily common-sense personal interpretation. However, while especially in this common-sense use, the hardware aspects of technology are emphasised, it makes sense to adopt Metcalfe's definition of technology

[48]Definition borrows from Arundel and Soete (1993,p.11).

> *as the ability to carry out productive transformations. It is an ability to act, a competence to perform, translating materials, energy and information in one set of states into another, more highly valued set of states...it is vital to distinguish technology as three interdependent forms (Layton, 1974): as knowledge, as skills and as artefacts (Metcalfe, 1995, p.37).*

Especially the knowledge/skills aspects of technology are crucial to our discussion, since they form the core of the systems/evolutionary approach to innovation.
As Smith (1995) has argued, in the neoclassical approach knowledge must be generic, codified, costlessly accessible and context-independent in order for production theory to be relevant.[49] Clearly, this view of knowledge is incompatible with the systems/evolutionary view presented above. Here knowledge and learning are at the heart of economic development and may not be generic, partly tacit, involve high transaction costs and surely depends on contextual/institutional setting[50]. Knowledge no longer can be equated with know-how in the 'Arrowian' sense, but may now involve know-what, know-why, know-how and know-who (David and Foray, 1994).
All this has led to the fact that *market-failure-approaches* to technology policy, based on the idea that government involvement is necessary in knowledge-creation due to indivisibilities, uncertainty and externalities involved in this process[51], no longer are a solid theoretical rationale for policymaking. In light of the learning/knowledge focus in the systems view it simply is plain wrong to treat knowledge without addressing its institutional surroundings, cumulative character and degree of codification. This criticism, combined with a lack of development of concrete alternative views, has resulted in the fact that

> *..although the pace of reform within the framework of structural adjustment strategies continues, a major obstacle now starting to emerge is the lack of rules of the game for the promotion of technological development (Chabbal and Guinet, 1993, p.ix).*

Now then, after having discussed why an evolutionary approach to ITP is inherently problematic, and having dispensed with the traditionally dominant market failure approach to ITP, what can we offer instead? It is to this we turn in the next section.

---

[49]The generic aspect means it can be widely applied, while the codified feature implies transmitability.
[50]See Johnson, 1992.
[51]For the seminal article on this see Arrow, 1962. For a similar earlier article which focuses on basic science rather than knowledge creation in the firm, see R.R. Nelson, 1959.

3.2 Towards an evolutionary ITP theory

> It should be noted that within this [neoclassical] framework there is nothing particularly important about technology policy: technological change is just one of many phenomena whose properties involve some degree of market failure. It has no more intrinsic value than, for example, a case of imperfect competition.
>
> K.Smith (1991, p.258)

> Technology and innovation policy is not therefore an activity of equivalent importance to other arenas of market failure. Technological performance has quite direct effects, unlike any other category of economic activity, on the long-run productivity growth rate, on the balance of payments, and on the tax base (and hence on public finance) For that reason, it ought to be of central concern of economic policy....Such points do not of course imply that technology policy as such ought to be at the centre of economic policy; rather, it is technological performance which becomes a fundamental object of policy in an evolutionary framework. The innovation activity of firms responds to a wide range of policy measures, from the general macroeconomic stance to such areas as contract law and accounting regulations; the problem is to investigate whether these arenas of policy can be integrated with innovation objectives in a consistent way.
>
> K.Smith (1991, p.267)

One of the earliest attempts, and unfortunately still one of the few, to develop an evolutionary ITP framework is the article "Innovation Policy in an Evolutionary Context, by Keith Smith. In this section I will draw mainly upon this article and the ones by Metcalfe. Finally, a recent report by the Commission of the European Communities will prove useful to merge these more theoretical contributions with some practical ITP issues. While some other sources will be drawn upon, it is unfortunately still the case that most books/articles have a short last section called policy conclusions /implications, that are dealt with in a similar vain as items for future research[52]. Based on what we have seen in the second chapter, it is clear that in the evolutionary world view "it is always possible to do better", and "only God knows what policy truly would be optimal" (Nelson and Winter, 1982). Indeed, the question becomes if we can identify routes to improved performance, and if these form any consistent pattern (Smith, 1991). Smith rightly rejects optimality concepts to fulfil the yardsticks for answering this question, and instead suggests that an evolutionary normative framework should be structured around the

1. variety generating forces
2. the selection mechanisms
3. the interaction between institutional structures and strategic behaviour

[52]While initially my intention in this PhD was to contribute to the filling of this gap, I have as we'll see, moved away from this and instead looked for inspiration in strategic management theory.

A fine balance between variety and selection needs to be struck. Thus, since selection is myopic the risk is always present that the population adapts 'too well' to prevailing circumstances, possibly leading to a lack of variety which needed when the changing environment demands new types of behaviours (Smith,1991). Or, as Metcalfe puts it:

> *..the policy problem becomes one of confronting the evolutionary paradox that competitive selection consumes its own fuel, destroying the very variety which drives economic change (Metcalfe, 1995, p.30).*

While this balance may at first seem an impossible utopian aim for ITP, this may not be the case. Thus by focusing on increasing experimental behaviour in the economy, the evolutionary policymaker is *adaptive*, and is mostly concerned with influencing the process by which firms develop the capabilities to deal with change.
This adaptive policymaker realises that the uncertainty and bounded rationality that face economic agents, also affect his decision-making, and, consequently his ambitions should not be to control and steer but rather to catalyse and reinforce endogenous experimental behaviour on part of the economic agents. Failure to grasp this may only replace market failure with 'government failure'. This outcome is shared with what is called the structuralist perspective on economic growth (Justman and Teubal,1990;1991).
This structuralist perspective emphasises that in order to generate/sustain economic growth, structural changes are necessary which unlike in the neoclassical framework are automatic by-products of capital accumulation and income growth. In this view, structural changes are 'causes of growth' rather than 'outcomes', and due to likely market failures in generating these structural changes, ITP is in some cases necessary. Like in the evolutionary approach, the importance of learning, capabilities and necessity for strategic choices are emphasised, but in contrast to the 'pure' evolutionary approach the market failure notion remains part of the framework. In a sense, the structuralist view then can be seen as a bridge between the evolutionary and neoclassical approaches, and as an attempt to enjoy the best of both worlds.
In an interesting blending of different perspectives, Teubal (1994;1995) in recent years has moved towards more evolutionary terminology and modes of expression, while retaining a personal - structuralist - touch.
What is of importance here is his emphasis on a policy life cycle, and the need for learning on behalf of both industry representatives and government officials. This aspect, as we will see later in the articles, is leads in the view developed in this thesis to the desirability of a bottom-up approach to ITP.
Furthermore, Teubal emphasises the need for ITP that catalyses endogenous developments in industry.

While Metcalfe (1995) distinguishes between the optimising (neoclassical) and adaptive (evolutionary) policymaker, I would prefer to also stress the catalysing role of the evolutionary policymaker, and call him the adaptive **and** catalysing policymaker.
This combination of terms in my view better reflects the role of the evolutionary policymaker, which should be to strike a balance between the creation of efficient selection mechanisms and sufficient but not too much variety-creating forces[53].
This evolutionary ITP-emphasis on creativity/experimental behaviour, through stimulating endogenous learning in the economy rather than setting its priorities, is one major outcome of the evolutionary view on ITP
The other main outcome is the prime importance of coordination, and complementarity between policies in a world view where systems determine competitiveness.
Since firms are embedded in institutional contexts, and the economy is seen as one large interconnected web of search and learning activities, coordination becomes crucial (Gerybadze, 1992), and

> *A key policy issue arising from systems approaches is the need to identify and perhaps support nodal points in the creation and distribution system; these are likely to be changing over time: the innovation system is not a structure, but a dynamic process (Smith, 1995, p.83).*

Recently, a very interesting perspective on this has been provided by David and Foray (1994)[54]. Their claim is that an innovation system's functioning can be improved upon either by increasing the stock of knowledge, or by making the present stock more socially useful. They argue that focus has typically been on the former - knowledge generation - aspect, and that time has come to re-create a balance and start aiming policies to improve the distribution of the existing stock.

---

[53]Maybe wrongly so, but to me the adaptive policymaker sounds like someone sitting back in his chair following events and then reacting to them. However, the catalysing part also should be emphasised in that sometimes he needs to get up from this chair and set experiments in motion of which indeed he does not yet not foresee the outcome and at a later will have to adapt to.
[54]They develop the interesting notion of a *knowledge-product-space* which is based on a classification of knowledge in terms of degree of codification, completeness of disclosure and ownership status.

Consequently, they develop the central concept of *distribution-power* of an innovation system, which characterises the "capability to ensure timely access by innovators to the relevant stocks of knowledge".
This in turn leads to the identification of distribution-oriented systems, in which "the institutions, incentive mechanisms and coordination arrangements have the following proximate objectives (David and Foray, 1994, pp.45-49):

1. *Encourage innovative agents to enter into cooperative games, based on the reciprocal and successive production and exploitation of complementary additions to the stock of knowledge*

2. *Reduce the uncertainty of institutional incompatibility*

3. *Enlarge the space of the search for information so as to increase the potential area of knowledge exploitation*

4. *Increase the relative importance of codified knowledge*

This approach combined with the work on NSIs, and evolutionary policy approaches will hopefully in the future produce some more tangible results of the newer innovation theories that are relevant as a rationale for policymaking. In fact this dissertation in part has attempted to contribute to this, while in the process though moving towards a 'mix' with recent strategic management theories (see Chapter 4). In the next section though an 'evolutionary proper' approach of considerable practical relevance will be shortly described.

3.3 Contemporary concrete policy output of the systems perspective

> Nelson's statements (since 1967) that market-failure analysis represents an incomplete basis for policy can be extended and applied in connection with evolutionary theory as well. More specifically, while it is important to emphasize the implications of variety, learning, institutions, and alternative selection mechanisms for policy, this is an incomplete basis for what could be termed an integrated "evolutionary technology policy". Moreover, a technology policy framework is becoming more and more important, because of the increasingly systemic nature of national innovation systems and the corresponding increased dependence of the impacts of any one policy on the nature and scope of other policies.
>
> M.Teubal (1995, p.43)

That indeed it is possible to combine evolutionary/systems approaches with practical policy advice work is demonstrated in a uniquely well-written report to the Commission of the European Communities.
According to Arundel & Soete (1993, p.26), the editors of this report that summarised brain-storming meetings of a group of experts, a good theory to guide policy should have the following objectives:

- *Helping people to apprehend reality*
- *Construct explanations*
- *Identify Options*
- *Decide on actions*
- *It should be operational, i.e. the policies can be developed, implemented and managed within the existing structure of government.*

In trying to meet these goals they present the systems approach to technical change, and try to outline its implications for ITP policymaking. They single out five main characteristics of the systems approach to technical change which are that (Arundel and Soete, 1993, p.36):

1. *Multidirectional links at the same point in time between stages of technical change.*
2. *Cumulative processes over time can lead to feedbacks and lock-in effects.*

3. *Technical change is dependent on knowledge and the assimilation of information through learning.*

4. *The details of the development path and diffusion process for each innovation are unique.*

5. *Technical change is an interdependent and systemic process*

The approach is then developed which leads to the following table with very concrete policy suggestions/implications for each of these systems properties.

Table 3.1

Major Characteristic	*Aggregate Policies*	*Firm-specific Policies*
1.Multi-directional linkages at the same point in time	• Provide developed communication and transport systems • Support networking and cooperation among and between research institutions and firms and the infra-structure of supporting services	• Support research and education that improve the organisation of innovation
2.Cumulative process over time	• Design policies to minimize undesirable linkage and feedback loops • Force a switch from diversity to standardisation when needed • Policies to support faster diffusion rates if of benefit	• Policies to assist firms in unlearning when needed and to develop new areas of expertise
3.Dependence on knowledge and the assimilation of information	• Maintain an educated and skilled workforce • Support transfer and inter-disciplinary sciences	• Provide support for the retaining of staff • Technology transfer and demonstration programmes
4.Each innovation is unique	• Broad range of programmes to support diversity • Appropriate mix of both general and specific policies	• Preserve a diversity of future options by nurturing the technological capacity of firms • Develop customised programmes to deal with the specific needs of SMEs
5.Interdependent system	Ensure complementary and coherent policies	

Source: Arundel and Soete (1993, p.38)

While it goes beyond the scope of this section to put this whole table in perspective let me single out one issue; the policy options associated with lock-in of technological change (see 2. cumulative process over time).

This possible lock-in effect is a much discussed matter in evolutionary theory, and a well-known example is Paul David's discussion of the QWERTY keyboard of the typewriter/computer (David, 1985).
While it thus can now be shown that this keyboard-layout is not the most efficient one, we have simply been 'locked in'.
Thus, I don't even think we can begin to imagine what it would demand in terms of retraining of especially secretaries to shift to a more efficient layout ! Policies to prevent lock-in are a difficult matter, since they have to be balanced with the needs for standards and reduction in uncertainty that are 'socially desirable' when the technology which is locked-in at stake is desirable. The report, very much in line with the adaptive/catalysing policy-maker discussion above, emphasises that rather than 'picking winners' policymaking should mainly ensure a diversity of (technical) options, and guide the direction and pace of technical change rather than picking winners. Based on this philosophy the following table on how policies might deal with cumulative lock-in is developed.

Table 3.2

Timing	*Information Available*	*Policy Options*
Before	Very Poor	"Wait and see"
Before	Some evidence that the technology is inferior to alternatives or creates negative externalities	Preserve other technical options by delaying standards or subsidising alternatives
Before	Strong evidence that the technology is undesirable	Redirect investment through regulations, standards favouring other alternatives, subsidies, ore procurement policies
Before\After	Technology is beneficial	Increase speed of diffusion if there are market social benefits
After	Strong evidence that the technology is undesirable	Support search for alternative solutions, create a sufficient "escape velocity" by subsidising an alternative technology

Source Arundel and Soete (1993, p.70)

While I believe the table speaks for itself it is necessary to point out that some of these policies may seem 'wasteful' in the sense that it would have been possible to do better. It should be emphasised however that this fact that 'had we known..' then 'we could have...' is an inherent property of evolutionary processes and that in hindsight all evolutionary processes look wasteful (Nelson and Soete, 1988). While the report discussed in this section is a step in the bringing down of evolutionary economics to a more practical policy orientation, in my view to become truly operative economics has to link up to strategic management theory. The next section explains why.

3.4 Why we still need to go beyond evolutionary and systems theory

> New tools and perspectives are becoming available which allow us to think of economies as evolving, emergent structures in which the creative activities of firms play a powerful role. But no firm acts in isolation; the wider institutional matrix is of vital importance to a clear understanding of innovation performance. As this field of enquiry develops the management literature will play a full role in identifying relevant sources of variety in behaviour and the inherent imperfections and grains of grit which typify all real world decisions processes.
>
> J.S.Metcalfe (1994, p.34-35)

From the first pages of this dissertation the direction has been to portray a theoretical landscape in which firms are part of a system which can enhance/retard innovation. In the evolutionary world-view strategy takes on a more prominent role than in traditional neoclassical analysis, since besides the impossibility to optimise (leading to a need for strategic behaviour), fundamental uncertainty about the behaviour of competitors calls for competitive strategy formulation (Smith, 1991)[55].
Consequently, policymaking takes on the role of affecting those factors that inhibit or enhance certain types of firms strategies. While it to an outsider perhaps would seem natural to link up to the literature on strategic management, the difficulties in doing so should not be underestimated. Thus, economics and management science have been almost entirely free of cross-fertilisation, and have not had many similar items on their research agendas. This was described in a humorous manner in an article called "An economist takes tea with a management guru" (The Economist, 1992). There Susan Emolument (the "guru") in answer to a question posed by old study friend Howard Parameter (the economist) on why the gurus aren't more interested in what the economists are up to, answers:

> *I've just remembered why we never got on. Hasn't it occurred to you that the big difference between economists and management scientists - please don't say gurus - is that economists just talk to each other, whereas management scientists, the more successful ones anyway, talk mainly to managers? And get paid for it by the way. Economics is so unbelievably inward-looking (The Economist, 1992, p.97)*

[55]It should be mentioned though that in particular since the use of game theory really took off in the end of the 80s in economics, the analysis of strategic behaviour of economic agents increasingly is becoming an integral part of micro-economic analysis. Still the models applied would differ typically from their evolutionary counterparts in assumptions of rationality, optimising ad the types of uncertainty.

Fortunately however, it seems that recent developments in both (evolutionary) economics and strategic management, have provided a common language, which has given the two previously artificially separated disciplines something to talk about (Rumelt, Schendel and Teece, 1991;1994). Since the articles that are part of this thesis will show exactly how this cross-fertilisation has been/is/might take place, here I will only briefly touch upon why this in my view is crucial.
As we have seen in 1.1, Sundbo (1991;1994) has distinguished between three different kinds of paradigms in innovation theory: entrepreneurship theory, technology-economics and the strategic paradigm.
Disregarding here his daring proposition that each Kondratiev wave 'demands' its own innovation paradigm since it is based on different innovation factors, it is fair to say that his taxonomy is very useful for analytical purposes.
In his analysis he more or less concludes by introducing the following table.

Table 3.3

Theoretical Paradigm	***Entrepreneurship Theory***	***Technology-Economics***	***The Strategic Paradigm***
Main Innovation Factor	Entrepreneurship	Technological development/ change	Market-oriented strategy
Explanation of Innovation	Psychological	Technological	Sociological
Agent	The 'Amateur'	Technician	Professional Manager
Outcome	Economic Growth and Business Development		

Source: Sundbo (1994, p.203)[56]

According to Sundbo the three paradigms are dictated by different 'market logics', where the entrepreneurship paradigm focuses on emerging markets, technology-economics on established but unexploited markets, whereas the strategic paradigm focuses upon 'saturated' markets which are complex and changing rapidly.
As a consequence of this, Sundbo argues, technology has become less of a potential source of competitive advantage than the capability to 'interpret markets' and develop the appropriate marketing strategy accordingly[57].

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[56]This is based on Sundbo, 1994, p.203. However the translation from the Danish is rather 'free' by the author in order to serve clarity.

[57]An interesting article which links these 'marketing' ideas with the resource-based approach (which will be discussed in chapter 3 and forms a central part of this project) is Day (1994). He argues that while the marketing concept has been around for over 40 years, only recently (last five years) have conceptual and empirical studies began to shed light on what market orientation really is and consists of. This may indicate that it is the theories rather than economic reality that has changed, and with them our perception of the sources of competitiveness. This possible challenge to Sundbo's framework goes beyond the scope of this thesis however.

While Sundbo probably exaggerates somewhat the technology-focus of technology-economics, he seems right in emphasising the need for a broad innovation concept which goes beyond 'technical change' and which necessitates strategy analysis.
Before turning to chapter 4, which deals with strategic management theory, and how to link it to evolutionary economics, let me illustrate that technology-economists are aware of the limitations of a technology-focus by quoting one of its main proponents, Richard Nelson:

> *I want to put forth the argument that it is organizational differences, especially differences in abilities to generate and gain from innovation, rather than differences in command over particular technologies, that are the source of durable. not easily imitable, differences among firms. Particular technologies are much easier to understand, and imitate than broader firm dynamic capabilities (Nelson,, 1991, p.72)*

Or, as Lars Kolind managing director of very successful Danish hearing aid producer Oticon A/S put it,

> *We want to build a company on the principle that people take responsibility, when they are offered responsibility. We will develop in a belief that employees themselves will find the way, when the leadership points out the general direction. If we succeed to implement these ideas throughout the whole company, we will become invincible, I think. This since Siemens and Philips may copy our circuits (technology, my addition), our design and business concept. The other thing they will never manage to do*[58].

Kolind's statement implies a firm strategy that focuses on the development of difficult-to-copy organisational routines as a source of competitive advantage. This links us naturally to chapter 4, where we will see that this is a central part of the resource-based view (RBV) of the firm which plays a central role in this thesis.

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[58]Translated from Poulsen (1993, p.64) At a single company-level one can probably not present a more spectacular example of new organisational configurations aimed at improving innovative capabilities, than Oticon A/S. This Danish hearing aid manufacturer which was founded in 1904, has as a result of its revolutionary way of reorganisation been presented in CNN's *Future Watch*, and even deserved its own chapter in a recent book by management guru Tom Peters (1992). After having lost market share in the beginning of the 90s, the company has completely revolutionised its organisational structure tending as they say towards a *spaghetti-structure* in which employees, management and projects are completely "interwoven". While providing hearing aids - prostheses - "used to be" the core business, the declared corporate mission now has become to provide *better hearing*. In fact this transition is viewed by the company as the transition from a manufacturing company to a service company.

4

The Resource-based Approach

4.1 A short history of strategic management theory

..strategy research is like pornography - it defies precise definition -, but one knows it when one sees it !

E. J. Zajac (1992, p.70)

Since the 1950s the field of strategic management has undergone quite a few changes in dominant themes, focus, concepts and the resulting organisational implications, as illustrated in table 4.1 below (which continues on the next page)[59].

Table 4.1

Period	*1950s*	*1960s*	*1970s*	*Late 1970s & early 1980s*	*Late 1980s & early 1990s*
Dominant theme	Budgetary planning & control.	Corporate planning.	Corporate strategy.	Analysis of industry & competition.	The quest for competitive advantage
Main focus	Financial control through operating budgets.	Planning growth.	Portfolio planning.	Choice of industries, markets, & segments and positioning within them.	Sources of competitive advantage within the firm. Dynamic aspects of strategy.

[59]In the table, SBU stands for Strategic Business Unit, HQ for Headquarters, PIMS for Profit Impact of Market Strategy, MIS for Marketing Information System and finally HRM for Human Resource Management.

Table 4.1 continued

Period	*1950s*	*1960s*	*1970s*	*Late 1970s & early 1980s*	*Late 1980s & early 1990s*
Principal concepts & techniques	Financial budgeting. Investment planning. Project appraisal.	Market forecasting. Diversification & analysis of synergy.	SBU as unit of analysis. Portfolio planning matrices. Analysis of experience curves and returns to market share.	Analysis of industry structure. Competitor analysis. PIMS analysis.	Resource analysis. Analysis of organizational competence & capability. Dynamic analysis: analysis of speed, responsiveness, & first-mover advantage.
Organizational implications	Financial management as key corporate function.	Development of corporate planning depts... Rise of conglomerates Diffusion of M-form.	Integration of financial & strategic control. Strategic planning as a dialogue between corporate HQ and the divisions.	Divestment of unattractive business units. Active asset management.	Corporate restructuring and business process reengineering. Building capabilities through MIS, HRM, strategic alliances, and new organizational forms.

Source: Grant (1995, p.17)

While the foundation of strategic management as field owes much to Alfred Chandler, Igor Ansoff and the Boston Consulting Group[60], commonly Kenneth Andrews is regarded as the founder of the field (Rumelt, Schendel & Teece). He defined strategy

> *as the match between what a company* can *do (organizational strengths and weaknesses) within the universe of what it* might *do (environmental opportunities and threats) (Andrews 1971).*

a definition which despite the changes described above still can be regarded as describing the lion's share of current strategy research. Thus, it is fully compatible with more recent and precise definitions like :

[60]The Boston Consulting Group introduced two major conceptual inventions: the experience-curve and the growth-share matrix.

> *A **strategy** is the* pattern *or* plan *that* integrates *an organization's* major *goals, policies, and action sequences into a* cohesive *whole. A well-formulated strategy helps to* marshal *and* allocate *an organization's resources into a* unique and viable posture *based on its relative* internal competencies *and* shortcomings, *anticipated* changes in the environment, *and contingent moves by* intelligent opponents. *(Quinn,1991, p.5)*

While several competing schools could be and still can be distinguished[61], the modern strategic management field started in the early 1980s when the field acquired tools from its 'sister-discipline' economics (Mintzberg, 1990). Michael Porter's 1980 book, Competitive Strategy: Techniques for Analyzing Industries and Competitors , is generally regarded as having been the main cause of this 'revolution', by rather successfully applying the techniques of industrial organisation economics to issues of competitive strategy (Levinthal & Myatt 1994).
By building on the structure-conduct-performance paradigm of industrial organisation economics[62], he identified the following five structural competitive forces that determine the average profitability in an industry: entry, threat of substitution, bargaining power of buyers, bargaining power of suppliers and rivalry among current competitors (Porter, 1980). This state of industry then sets the context for the strategy the single company should follow, where it can choose between three main alternatives :

- *positioning the firm so that its capabilities provide the best defense against the existing array of competitive forces;*
- *influencing the balance of forces through strategic moves, thereby improving the firm's relative position; or*
- *anticipating shifts in the factors underlying the forces and responding to them, thereby exploiting change by choosing a strategy appropriate to the new competitive balance before rivals recognize it. (Porter, 1980, p.30)*

While the sudden rigour and systematic framework for analysis surely today are seen as having positively contributed to strategic management theory, the analysis simultaneously led to a focus upon industry-level analysis at the expense of thorough treatment of the single firm.

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[61]Mintzberg (1990), distinguishes between ten schools: the *design, planning, positioning, entrepreneurial, cognitive, learning, political, cultural, environmental and configurational* schools.
[62]This structure-conduct-performance paradigm is often associated with J.S.Bain's early work for instance, See Bain (1951) For more on the origins of this school see Conner (1991).

This implied that the traditional SWOT-analysis (Strengths, Weaknesses, Opportunities and Threats) which has been dominating since the work of Andrews, now mainly focused on the OT-part of the analysis. As convincingly argued by Teece, Pisano and Shuen, a firm's entry decision in this competitive strategy framework looks as follows (Teece, Pisano & Shuen, 1990, p.15):

1. *Pick an industry (based on its "structural attractiveness).*

2. *Choose an entry strategy based on conjectures about competitors' rational strategies.*

3. *If not already possessed, acquire or otherwise obtain the requisite capabilities to compete in the market.*

During the 1980s there emerged growing dissatisfaction with the competitive strategy framework.
This, due to increasing competition **within** industries, blurring industry boundaries, and especially since empirical research did not substantiate the main claim that industry structure determined firm conduct and hence its performance (Grant, 1995)[63]. As Collis and Montgomery (1995) argue, the initial theoretical response to this was an extreme focus upon a firm's internal state of affairs in terms of its capabilities and competencies. Indeed, the already classic 1990 article by Hamel and Prahalad on the core competence of the corporation confirms this claim when it is stated that:

> *In the long run, competitiveness derives from an ability to build, at lower cost and more speedily than competitors, the core competencies that spawn unanticipated products. The real sources of advantage are to be found in management's ability to consolidate corporate wide technologies and production skills into competencies that empower individual businesses to adapt to quickly changing opportunities (Hamel and Prahalad, 1990, p.81).*

[63]As Grant refers R.P.Rumelt (1991) found in a study that among 2.180 business units, only 4 % of the variance of return on assets was attributable to the influence of industry. Black and Boal (1994), refer to evidence pointing at an industry influence of between 8-15%.

And Stalk, Evans and Shulman stated only two years later the following four principles of capabilities-based competition:

1. *The building blocks of corporate strategy are not products and markets but business processes.*

2. *Competitive success depends on transforming a company's key processes into strategic capabilities that consistently provide superior value to the customer.*

3. *Companies create these capabilities by making strategic investments in a support infrastructure that links together and transcends traditional SBUs and functions.*

4. *Because capabilities necessarily cross functions, the champion of a capabilities-based strategy is the CEO. (Stalk, Evans and Shulman, 1992, pp.62-64)*

While this swing from the outside to the inside was understandable, again an unbalanced framework emerged, which nearly completely ignored the impact of the external environment on firm strategy.
Since very recently however, a balance between the focus on internal and external factors influencing firm strategy is re-created in the emerging resource-based view of the firm. This approach, stresses the importance of both firm-specific resources and capabilities, while treating the 'environment' as the factor that determines the value of these. By grounding itself, like the competitive strategy tradition, in economics, and addressing both the SW and OT part of SWOT-analysis this framework seems to have a lot of potential to become a 'grand theory' of strategic management. Let us now turn then to what it is all about.

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[64]It is interesting to note the similarity in title (Competing on capabilities...) with the HBR 1995 article by Collis and Montgomery (Competing on Resources....), which in a ways seems to 'replace' it.

4.2 The Resource-based View

> ..I suspect that we soon will drop the compulsion to note an argument is 'resource-based'. Basing strategies on the differences between firms should be an automatic, rather than noteworthy.
>
> B. Wernerfelt (1995, p. 174)

According to Schulze, there are three defining assumptions which characterise all research which fall under the heading RBV (Schulze, 1994):

1. *Differences in resource endowments are causally related to differences in product and service attributes, and thus to differences in firm performance.*

2. *The resources needed to conceive, choose, and implement strategies are heterogeneously distributed across a set of competing firms .*

3. *Firms are rent-seekers* [65].

These defining characteristics of the RBV, indeed will be agreed upon by most authors within the 'tradition' that dates back to 1984. In that year Birger Wernerfelt, published his article, A resource-based view of the firm, in the Strategic Management Journal and founded the tradition[66].
Building upon Penrose's work (Penrose, 1959), the RBV differs from the competitive strategy school in assuming that firms within an industry may be heterogeneous due to the different 'resource-base' that they posses, and that this heterogeneity maybe long-lasting since these resources may not be perfectly mobile (Barney, 1991).
In the RBV the value of a resource, originally defined by Wernerfelt (1984) as "anything which could be thought of as a strength of a weakness of a given firm", is determined by its ability to exploit opportunities and/or neutralise threats[67].

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[65]Rent generally is defined as a return in excess of a resource owner's opportunity costs, see Tollison (1982) and Mahoney and Pandian (1992).

[66]Another often-cited early contribution to the RBV Rumelt (1984), where the firm is described as a 'bundle of unique resources'.

[67]See Wernerfelt (1995, p.172) and Barney (1992, pp.42-43). Presently most authors would distinguish between resources as the inputs into the production process, and capabilities which represent the capacity to employ these resources effectively and are the main source of competitive advantage, see Grant (1991). (Grant also distinguishes between financial, physical, human, technological, reputation and organisational resources). There are many different definitions of resources and capabilities but this one is compatible with most of them. Some prefer to distinguish

In other words, RBV analysis intrinsically links an analysis of a firm's internal state of affairs with a treatment of its external environment, since the value of its resources/capabilities depend on the potential to exploit these in the market place.
Barney, has developed a framework for determining the competitive consequences of resources that may have different exploitation potential, which is summarised in table 4.1.

Table 4.2 Estimating the return generating potential of organisational resources

Is a Resource				
Valuable	*Rare*	*Difficult to Imitate*	*Without Substitutes*	*Competitive Implications*
No	-	-	-	competitive disadvantage
Yes	No	-	-	competitive parity
Yes	Yes	No	-	temporary competitive advantage
Yes	Yes	Yes	No	competitive parity
Yes	Yes	Yes	Yes	sustained competitive advantage

Source: Barney (1992, p.43)

As Brumagim (1994) has argued the first 'test' concerning valuable/non-valuable refers to the degree of competitive advantage that the firm which own the resource may enjoy, while the other three categories determine the degree of idiosyncrasy.
While I believe the table speaks for itself, the last entry where a resource is valuable, rare, difficult to imitate and without substitutes needs elaboration. Resources that have these features, are the only ones that can lead to a sustained competitive advantage (SCA), which a firm is said to enjoy when,

> *it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors* and *when these other firms are unable to duplicate the benefits of this strategy (italics in original) (Barney, 1991, p.102)*

Now note that this is an 'equilibrium definition' of SCA, which boils down to claiming that a SCA exists when a firm employs a strategy which others find too costly to copy and hence will continue to exist after efforts to duplicate the advantage have ceased (Barney, 1991). Barney's main reason for adopting this equilibrium definition to avoid addressing the problem of the time-dimension in the SCA-concept.

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between well-defined routines/capacities to employ resources effectively - competencies -, and the mechanisms by which these competencies are formed - capabilities. (See Day (1994).

After having read chapter 2 however, the reader may with good reason ask how an equilibrium definition can be compatible with the framework of this thesis which after all is evolutionary/neo-Schumpeterian ?
To answer this question we must return two Schulze how in fact has suggested that the RBV might consist of two distinct and largely incommensurable camps.
One - the structural school - which is mostly economics-inspired and indeed involves notions such as equilibrium. The other - process school - is more behavioural theory based, and takes a dynamic non-equilibrium approach to resource-based analysis. According to Schulze the structural school adds the following assumption to the earlier identified three defining ones:

4. *Sustained competitive advantage is feasible if the resources used to achieve that advantage are rare, imperfectly mobile and non-substitutable*

However, the process school takes a broader interpretation and assumes that

5. *Efficiency rents are routinely available to the firm*

Based on these the following table can be developed which sets the two schools apart:

Table 4.3: The process and structural RBV

	Process Model	*Structural Model*
Analytical Condition	Dynamic	Equilibrium
Managerial Role	Create, Upgrade & Replace	Discover, Exploit & Protect
Probability that Managerial Action Has Positive Effects	Serendipity	Luck
Strategic Emphasis	Implementation	Formulation
Analytical Focus	Organisational Processes	Market Processes
Related Economics Discipline	Evolutionary	Neoclassical
Character of Research Design	Qualitative, Longitudinal	Quantitative, Formal
View on Resource Heterogeneity	Views Managerial Action, Complex Attributes of Organisations and Organisational History as those that make and sustain resource heterogeneity	Views Factor Market Failures and the Discrete Attributes of Factors as factors that account for resource heterogeneity
View of Entrepreneurship	Austrian	Schumpeterian

Source: Schulze (1994)[68]

Peteraf (1994), in commenting upon Schulze's article firstly points out that Schulze's distinction between the two schools in part is based on confusing usage of different types of rents, which does not withstand closer scrutiny. Consequently, she does not view the two schools as incommensurable and believes the two might "be brought together to form a greater whole". Still, she considers the distinction useful, and in doing so supports Levinthal who also distinguishes between two RBVs: A High Church and a Low Church branch largely equivalent to Schulze's structural and process schools respectively.
While the high church branch of the RBV, is linked to the neoclassical rational choice model and adopts some form of equilibrium thinking, the low church branch of the RBV

> *rejects these two assumptions. For these authors, the resource perspective seems to have two defining elements. One is simply an issue of the appropriate level of analysis with which to explore strategy issues. Heterogeneity across firms is of greater interest than heterogeneity of markets. A second, and related attribute, is that for the firm attributes that account for variation in profitability, factor inputs must be highly imperfect Levinthal, 1995, p.23).*

[68]The table is based on W.S.Schulze (1994, p137). Some modifications to his table are made though, leaving out some boxes adding others relevant to our discussion here.

Clearly I subscribe to the process/low-church school/branch. Since in my view it is up to those that consider theories incommensurable to proof this is so (Mahoney, 1992), I will adopt the evolutionary view and invoke this equilibrium definition. These in my view are compatible, and will be treated as such until proven otherwise. until proven otherwise. In the next section which will briefly consider the practical strategy implications of the RBV, as in the remainder of this thesis, I will hence treat the RBV as one school of thought[69].

4.3 Implications of the RBV for strategy analysis/ formulation

> That this [RBV] approach pays off is demonstrated by the impressive performance of companies such as Newell, Cooper, Disney and Sharp. Although these companies may not have set out explicitly to craft resource-based strategies, they nonetheless capture the power of this logic and the returns that come to those who do.
>
> Collis & Montgomery (1995. p.128)

While the competitive strategy school emphasised the quest for monopoly rents (returns to market power) as central to business strategy, the RBV emphasises the quest for Ricardian rents; the returns that accrue due to a resource quality differential and confer competitive advantage over and above the real costs of these resources (Grant 1991, Peteraf 1994)[70].
As a result, the strategy formulation process prescribed by the RBV looks quite different from the one described above that is associated with the competitive strategy school. Instead of a jockeying for favourable positions within an attractive industry, management's task now becomes to exploit the company's principal resources, ensure they are fully employed and exploited to the limit while building/maintaining the company's resource base (Grant 1995, pp119-120). Or, as , put it now the process of strategy formulation looks as follows (compare to section 4.1's competitive strategy sequence!):

---

[69]As a consequence, it does in my view not make sense to distinguish between the RBV as concerned with the (static) exploitation of firm-specific assets and a dynamic capabilities approach (DCA), concerned with the dynamic aspects. Some authors prefer to do so however, see Teece and Pisano (1994) The whole issue of the journal to which this article is an introduction, is dedicated to the DCA.

[70]Another definition is that Ricardian rents are "rents that accrue to the persistence of fixed, scarce factors and can persist in static equilibrium", Rumelt (1987, p.142). Montgomery (1995, pp262-263) remarks rightly though that "The analysis of Ricardian rents has added considerable sophistication to our understanding of resources and competitive advantages. It is regrettable, however, that these developments have not been balanced by a closer consideration of Schumpeterian rents, and resources and advantages that erode through time". For an exception and article that focuses on "the competitive processes through which resources must be sustained against attempts at imitation and substitution after the point in time at which resources become commercialized" Williams (1992, p.48).

1. *Identify your firm's unique resources;*

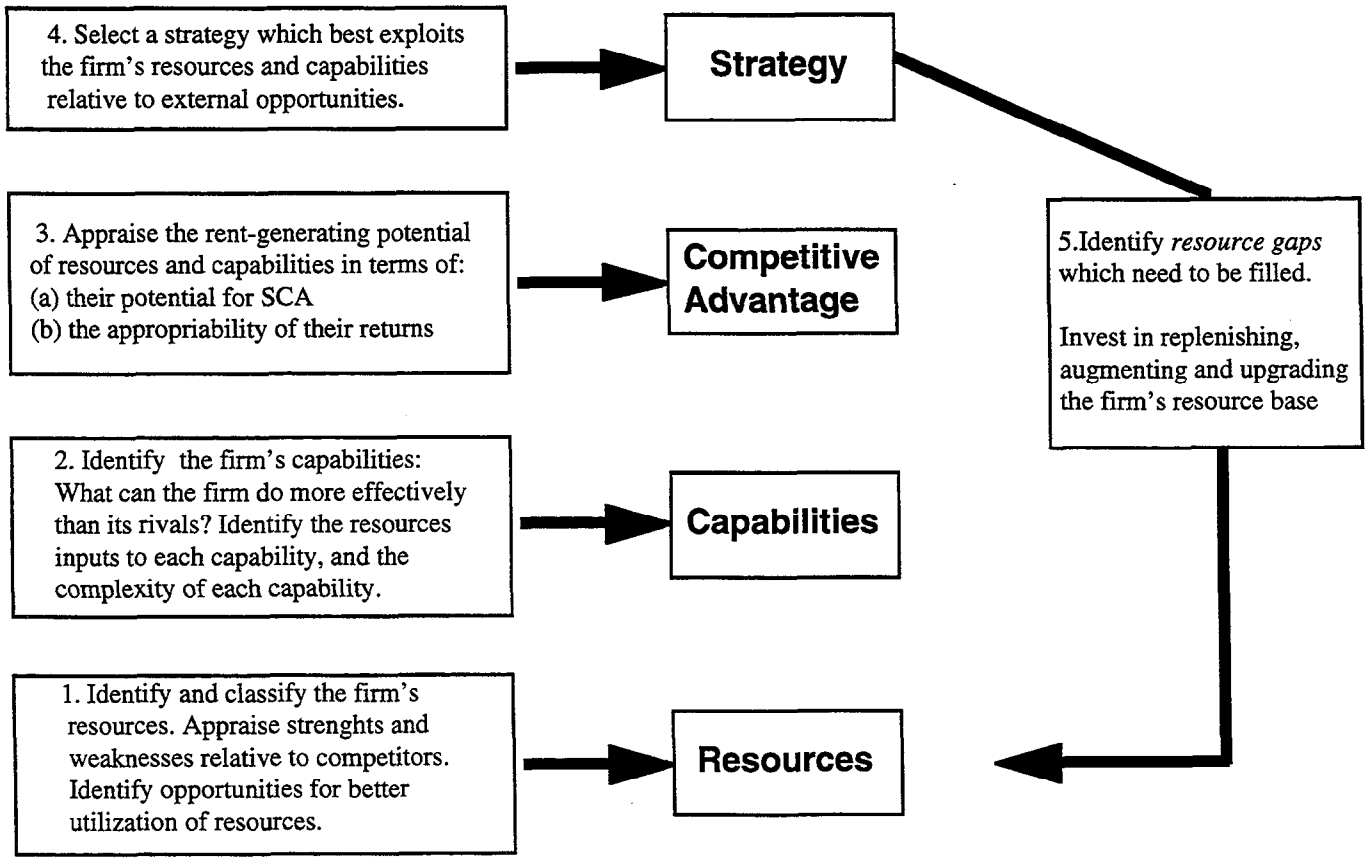
2. *Decide in which markets those resources can earn the highest rents; and*

3. *Decide whether the rents from those assets are most effectively utilized by*

   (a) integrating into related market(s),
   (b) selling the relevant intermediate output to related firms, or
   (c) selling the assets themselves to a firm in related business (Teece, Pisano and Shuen (1990, p.14)

Grant has pictured the process as follows, where the reader should pay attention especially to step 1 and 4 in the strategy formulation process, which clearly emphasise the need to perform both inside-out and outside-in analyses.

Figure 4.1: The RBV view of strategy analysis



Source (Grant, 1991, p.115)

Above (in 4.2.) we presented Barney's framework for assessing the return-generating potential of resources, which emphasised their degree of competitive advantage and idiosyncrasy. Grant has developed a similar framework where Barney's four characteristics are replaced by the following features resources may have to varying degrees (Grant,1991, pp124-128):

- durability — the rate at which the resources and capabilities underlying the SCA become *obsolete*
- transparency — the degree to which the resources and capabilities behind the SCA, and the resources and capabilities required for replication can be *identified* by competitors
- transferability — The extent to which it is possible for competitors to *acquire* the resources and capabilities behind the SCA requisite to enter competition
- replicability — The extent to which competitors can *replicate* the resources and capabilities behind the SCA *internally*

An assessment of a firm's resources in these terms along the lines depicted in Grant's figure above, in combination with an assessment of the appropriability of the rents the resources may generate then stand at the heart of RBV analysis. Or, we may end with the 5 RBV tests developed by Collis and Montgomery (1995, pp.120-123) to assess he value-generating and appropriability-features of a company's resources.

1. *The test of inimitability: Is the resource hard to copy?*
2. *The test of durability: How quickly does this resource depreciate?*
3. *The test of appropriability: Who captures the value that the resource creates ?*
4. *The test of substitutability: Can a unique resource be trumped by a different resource?*
5. *The test of competitive superiority; Whose resource is really better ?*

Especially the 5th test is crucial and links the internal and external part of the analysis most explicitly. In doing so, it differs from the core competence approach with almost exclusive focus on the 'inside' which "has too often become a feel good exercise that no one fails" (Collis and Montgomery, 1995, p.121).

4.4 Linking the RBV and evolutionary economics

> Students of firm management, in particular those working in the strategy field, treat discretionary firm differences as their bread and butter. Economists have tended to play down these differences, or to argue that they are the result not the cause of general economic differences. In good part the difference in viewpoints is due to differences in basic interests-the student of firm management concerned with the fate of individual firms, and the economist interested in general economic performance of an industry or A nation. But I have argued that the lack of interest in discretionary firm differences stems as well from a particular [neoclassical] theoretical view of economic activity and the role and behaviour of firms. If one takes an evolutionary rather than a neoclassical view of what economic activity is about, then firm differences matter importantly regarding issues that traditionally have been the central concern of economics.
>
> R.R.Nelson (1991, p.72)

This section is the last before we turn to the first article that is part of this thesis. Since in the articles an attempt is made to integrate the RBV, evolutionary view and ITP analysis, no such synthesising effort is made in this section. I would like however to point at one important issue that is not dealt with in the articles: the issue of routines. Firstly though, let me introduce a table , developed by Juul Foss, Knudsen and Montgomery, that compares the RBV and evolutionary theories[71].

[71] I have chosen not to copy the first entry of their table -'underlying economic theory' - since it does not correspond to my view on the matter. Thus, in contrast with my approach, the authors have chosen to focus 'only' on the High Church - Structural School - justifying their claim that the view is equilibrium-oriented (in contrast to evolutionary theory which is as they rightly state process-oriented). Besides this disagreement however, the table captures well the essence of the evolutionary and RBV approaches. The book which contains this article from which this table is adopted, is a collection of articles on the link between the RBV and evolutionary theories, that were presented earlier at a conference on the same topic in Snekkersten, Denmark, August 1993.

Table 4.4 Evolutionary and Resource-based Approaches: A Juxtaposition

	Evolutionary Theory	Resource-based Theory
Level of Analysis	Primarily industry	Firm
Units of Analysis	Routines	Resources
Intellectual Heritage	Schumpeter, Alchian	Penrose, strategic management tradition; Chicago industrial economics
Selected Contributors	Nelson/Winter; Metcalfe/Gibbons	Wernerfelt,Barney; Dierickx/Cool, Rumelt
Primary Object of Explanation	Technological evolution and competition	Sources of competitive advantage, diversification
Central Resources	Primarily intangible resources	In principle: all resources
Concept of Strategy	Articulation of routines in a profit-seeking way (generally not well-described)	The quest for Ricardian rents through the accumulation and deployment of non-imitable resources

Source: (Foss, Knudsen and Montgomery, 1995, p.10)

Central to both approaches is the notion of routines, which enable cumulative learning and are the guardians of the corporate memory.
As Montgomery (1995) has argued however, there is a fundamental difference in that the strategic management school treats routines with a positive connotation as a *proxy for inimitability* [72], while the evolutionary theorists focused on the concept as *a proxy for inertia*.. While this may be connected to a general tendency of strategists to be die-hard optimists - possible related according to Montgomery to the fact that few may hire a pessimistic consultant -, there is of course truth in both stories. In the article that follows no explicit discussion of routines as negative or positive factors is presented, but both are consistent with 'the story'.

[72] And hence as we shall see possible source of sustained competitive advantage.

Let me, before turning to the first article end on a positive note, and like Montgomery quote Dierickx and Cool (1989), in the paraphrasing of a dialogue between an English Lord and his American visitor to illustrate how routines can provide incontestable leads:

> *"How come you got such a gorgeous lawn?"*
> *"Well, the quality of the soil is, I dare say, of the utmost importance."*
> *"No Problem."*
> *"Furthermore, one does need the finest quality seed and fertilizers."*
> *"Big deal."*
> *"Of course, daily watering and weekly mowing are jolly important."*
> *"No sweat, jest leave it to me!"*
> *"That's it."*
> *"No kidding?!"*
> *"Oh, absolutely. There is nothing to it, old boy; just keep it up for five centuries."*

Pergamon

Technology In Society, Vol. 17, No. 4, pp. 413–428, 1995

0160-791X/95 $9.50+0.00

0160-791X(95)00017-8

Linking Firm Strategy and Government Action: Towards a Resource-based Perspective on Innovation and Technology Policy

Philip Wegloop

ABSTRACT. The author combines a variety of approaches that emphasize capabilities, skills, and competencies in developing a framework for innovation and technology policy that suggests innovation and technology policy should be strategic in nature. The main goal of this framework is to guard and update the knowledge-base of the institutions and actors that allow firms to recognize the value of external information, assimilate it, and apply it to commercial ends: national absorptive capacity (NAC). After presenting the framework, the author discusses a recent Danish innovation and technology policy exercise, the Resource Area Analysis (RAA), to illustrate the relevance of the approach.

Specialization, History, Matters and the Need for Strategy

Firms specialize. A firm's decisions on when and how to specialize and in what field to specialize depend on the particular expectations, insights, intuitions, and motives of its decision-makers. Firms are, as are human beings, unique, if only because the people comprising them are never the same. In addition, each person has different experiences that cause them to view events in different ways. As Nobel Laureate D. C. North has described how, on the basis of classifications that evolve from childhood and which are a reflection of past perceptions of experiences and analytic results, people form mental models, which form the basis for their present

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interaction with the external environment and color their present perceptions and experiences.[1]

Those that work in an organization may form "collective mental models." Hence, a firm's contemporary strategic choices can depend on its past and on its organizational form.

In fact, firms will, just as will people, develop their own unique character. Thus, over time, every firm will develop distinctive idiosyncratic resources and organizational routines that function both as constraints and as opportunities for its present and future behavior.

This also holds for networks of firms, industrial regions, and nations; history matters, and the present strengths, weaknesses, opportunities, and threats that are a reflection of the historical, institutional, and cultural past.

This description of organizations, which over the last decades has gained acceptance within academia is called "history matters" or "path dependency."

The Resource-based View of the Firm

The resource-based view of a firm emphasizes a firm's internal capabilities and resources as the basis for a strategy formulation and is an emerging strategic management approach that is being debated among scholars dealing with strategy, organizational economics, and industrial organization. It centers around a firm's heterogeneity, and allows one to view a firm's internal capabilities and resources as the central drivers behind its strategy formulation and economic behavior.

As R. M. Grant argues, this approach, in so doing, addresses an issue — the link between internal resources and strategy — that has been largely neglected at the expense of the other component of strategy: the link between strategy and the external environment.[2]

Central to the resource-based approach, as it is to nearly all strategic management literature, is the concept of sustainable competitive advantage (SCA). J. Barney defines sustainable competitive advantage as follows:

> A firm is said to have a *sustained competitive advantage* when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors *and* when these other firms are unable to duplicate the benefits of this strategy.[3]

The sustainability of competitive advantage is a function of four characteristics that a firm's resources and capabilities may possess to varying degrees:[4]

- durability — the rate at which the resources and capabilities underlying the SCA become obsolete;
- transparency — the degree to which the resources and capabilities behind the SCA, and the resources and capabilities required for replication, can be identified by competitors
- transferability — the extent to which it is possible for competitors to acquire the resources and capabilities necessary to enter into competition

- replicability — the extent to which competitors can replicate the resources and capabilities behind the SCA internally.

Together with the sustainability of its competitive advantage, a firm's ability to profit from the returns that the resources generate determines the firm's economic success.

It follows that firms should assess their value-generating resources and capabilities and devise a strategy that exploits the potential embedded in their accumulated "resource-base."[5]

For those unfamiliar with the literature on strategic management and industrial organization, this may seem an obvious and trivial outcome. It is not.

By emphasizing a firm's internal resource base as the main source of supra-normal organizational rents, the resource-based approach differs from the dominant school of strategy analysis: the environmental school.[6]

Those who subscribe to this theory, which was pioneered by M. Porter, view a firm's success mainly as a function of two variables:[7]

- the attractiveness of the industry in which the firm competes or
- the firms relative position in that industry.

While they recognize that a firm may feed upon its environment, and by doing so change it, they tend to view the SCA as being industry-driven. As a result, the main task for strategic management becomes the search for favorable positions.[8]

While he grants the resource-based view some merit, Porter is unwilling to accept the resource-based view as a full-fledged competitor to his theory. Thus, he states:

> The resource-based view has been proposed as an alternative theory of strategy. . . . As with the other literatures however, more work remains to be done. At its worst, the resource-based view is circular. . . . Yet the resource-based view cannot be an alternative theory of strategy. It cannot be separated from the cross-sectional determinants of competitive advantage or, for that matter, from the conception of the firm as a collection of activities. Stress on resources must complement, not substitute for, stress on market positions.[9]

On the other hand, one cannot deny that the environmental school's analytical innovation — SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis — has, as pointed out by J.A. Black and K.B. Boal, been applied mainly to opportunities and threats.[10] In particular, if the empirical evidence referred to by the latter is correct and only 8-15% of the variance in a firm's performance can be explained by industry structure, this is a serious deficiency.

Furthermore, in a world in which the external environment is changing continuously and increasingly rapidly, defining a firm's strategy on the basis of its resource-base is less risky than defining it on positional grounds. And yet, there exists:

an important complementarily between environmental models of competitive advantage and the resource-based model. These environmental models help isolate those firm attributes that exploit opportunities and/or neutralize threats, and thus specify which firm attributes can be considered as resources. The resource-based model then suggests what additional characteristics that these resources must possess if they are to generate sustained competitive advantage.[11]

As is illustrated by the case presented below, the resource-based approach can be usefully combined with the environmental school and extended to the macro-level.

From Micro to Macro: Resources and Evolution

To arrive at a new theory of innovation and technology policy, the framework must be extended beyond firm-level issues to a higher level of aggregation, which will be accomplished by combining the resource-based view with the evolutionary economic approach.

The evolutionary economic approach focuses on dynamic — technological — change and, in so doing, disassociates itself from the mainstream equilibrium approach in economics. In its modern version, the evolutionary economic approach began by defining its domain mainly as a negation of neoclassical propositions that include elements from behavioral and institutional economics.[12] It still has not reached as coherent a body of definitions juxtapositions as the mainstream neoclassical approach. To be evolutionary, however, an economic theory must conform to the following:[13]

- The analysis should be explicitly dynamic
- The analysis should explain economic behavior as a result of two opposing forces:
  - those involving a random element that create variety and those that select which of the various behaviors will survive
- The analysis should include cumulative processes.

The resource-based view fulfills all but one of these conditions.[14] Thus, it is expressly dynamic: history matters. The variety-creating forces are the development of distinct capabilities, skills, and competencies through learning, which result in idiosyncratic resource-bases that in turn result in firm-specific courses of action. The only element that is not immediately recognizable as part of the resource-based view is the specification of the selection environment. This can be attributed to the approach's existing on a micro-level: it deals with firm-level issues. In fact, the resource-based view may be described as one possible theory of the firm, which in order to gain evolutionary status needs to be supported by more macro-economic selection environment arguments.

Firms typically consist of groups of individuals who learn by doing, using, and interacting. In order to engage those individuals in collective learning processes, which are crucial to a firm's long-term competitiveness, common

codes of communication and common knowledge need to be established. Organizational routines become the backbone of the firm.

Part of this knowledge will be tacit. This produces heterogeneity among firms and creates difficult-to-copy organizational features that can cause different degrees of competitiveness. Because of this evolution of particular routines in specific contexts, path-dependency emerges. Therefore, at the macro-level, there is a wide variety of firms that embody diverse behavioral patterns and their own way of looking at the competitive world. Finally, external structural changes constantly redefine which of a firm's historically developed resources can serve as a basis for competitive advantage and which cannot. In the end, in other words, the winners and losers are picked by the selection environment, which itself is constantly in flux due to changes in behavioral patterns at the firm-level.

Linking Micro, Macro and Policy: Why Policy at all?

Every industrialized economy faces many structural changes that occur more often and are of a more complex nature than ever before. In addition, countries tend to specialize in certain industrial sectors; these specialization patterns change slowly over time.[15] The result is that no country can consist of companies that follow the developments of, and are willing to invest in, all of the structural and technological changes that are under way; 99% of new science and technology comes from outside of Denmark's borders.[16]

Since firms cannot internally develop all requisite factors that are or might be in the future relevant to their area of business, they need absorptive capacity. This concept was introduced by W. M. Cohen and D. A. Levinthal and reflects "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends."[17]

The ability to absorb and interpret new knowledge depends on the quantity and quality of knowledge accumulated in the past. Thus, a firm cannot by itself make sure that its absorptive capacity stays up-to-date, since it will over time focus on developments that fit with its path-dependent track-record.

The idiosyncratic resources that form the basis of competitive advantage, and hence should be pursued by a firm, may constrain a firm's capability to keep an entirely open mind to new opportunities and developments. Cohen and Levinthal use the term "lockout" for the extreme condition in which:

> once a firm ceases investing in its absorptive capacity in a quickly moving field, it may never assimilate and exploit new information in that field, regardless of the value of that information.[18]

This results in governments assisting firms in maintaining and updating their absorptive capacities, since market failure at the firm-level in the development and maintenance of the absorptive capacity is not only possible but inevitable.

Firms will focus and lockout, and governments need to play the roles of

complementary assets: resources on which firms can draw to uphold their absorptive capacity. D. J. Teece argues that:

> If government decides to stimulate innovation, it would seem important to clear away barriers which impede the development of complementary assets which tend to be specialized or cospecialized to innovation.[19]

I take this argument one step further and suggest that the governments should be complementary assets, not merely actors that reduce obstacles to their development or substitutionaries. Thus, governments should catalyze endogenous development within firms and leave the setting of priorities to those who know most about the firms: the people who run them.

Why Policy at the National Level?

During the last few years, an extensive debate has emerged on what the appropriate level of innovation and technology policy is or should be. In particular within Europe, the division of policies between those best left at a national level and those requiring unified European initiatives is under constant revision and scrutiny. On the other hand, an increasing number of researchers point to the importance of the regional level in socio-economic development and advocate policies at this level. I believe that the national level should be the center of attention.

As is described in recent literature, national similarities in culture, language, and geographical proximity help foster the growth of national systems of innovation (NSIs).[20]

This concept seems to be intuitively clear, but very difficult to explain analytically. Typically, one either presents his own definition of the NSI or circumvents the issue.[21] I have chosen the first option and defined the NSI as a set of actors and institutions, both inside and outside national borders, that contribute to the innovative capabilities within a nation.

Therefore, the national designation of the NSI does not reflect the fact that the actors are situated within the nation, but that the institution contributes to innovation within that nation.[22]

Wijnberg argues that national systems of innovation need to be defined in terms of policies, rather than in terms of actors or networks, for the concept to become relevant for policymaking. In particular, he argues that what is needed is a model of NSIs that allows for comparative analysis and, if combined with evolutionary hypotheses, could form the basis for concrete policy recommendations. While I agree with these goals, the framework developed by Wijnberg cannot be applied to the current analysis, since absorptive capacity resides in certain agents, be they individuals, firms, or governmental institutions, but not in the policies.[23]

M. Humbert, in a recent article concerning the background and nature of strategic industrial policy, argues that history has implications for one's view on resource allocation.[24] Thus, maximizing the probability of long-term success becomes more important than allocating resources optimally in the

present. With government protecting the nation's capability to follow external developments, companies are enabled to take a less myopic view of resource allocation. While Cohen and Levinthal refer to an earlier focus on the individual firm and the impact of this absorptive capacity on innovation and learning in the organization, it seems worth applying this concept on a national level as well. In fact, it seems useful to define the National Absorptive Capacity (NAC) as those institutions and actors that allow firms within the NSI to recognize the value of new external information, assimilate it , and apply it to commercial ends.

This NAC concept fits within the theoretical framework of distribution-oriented innovation systems.[25] This concept also emphasizes that NSIs should be characterized by their distribution power, i.e.:

> by the system's ability to support and improve the efficient functioning of procedures for distributing and utilizing knowledge.[26]

While this definition reflects the efficiency of the system from the supply side — its distribution power — the NAC concept stresses the importance of the system's efficiency on the demand side.

The Only Way is Up: Bottom-up

When a government develops and implements an innovation and technology policy, failure is always a possibility. I believe that this is a risk worth taking.

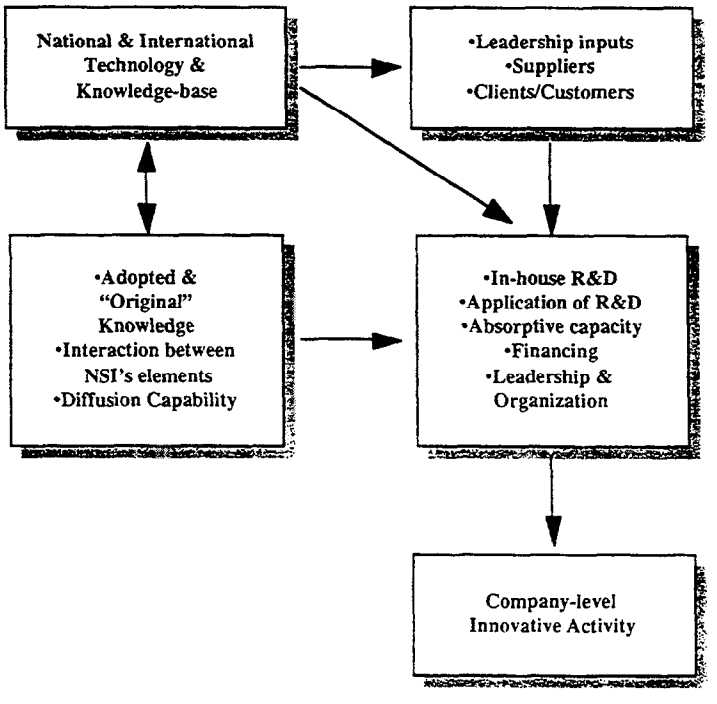

Figure 1. IDTC's View of the Danish NSI. [Source: Erhvervsudviklingsradets Redegorelse, Ervervs Udviklings Radet (IDTC), 1994, p. 62]

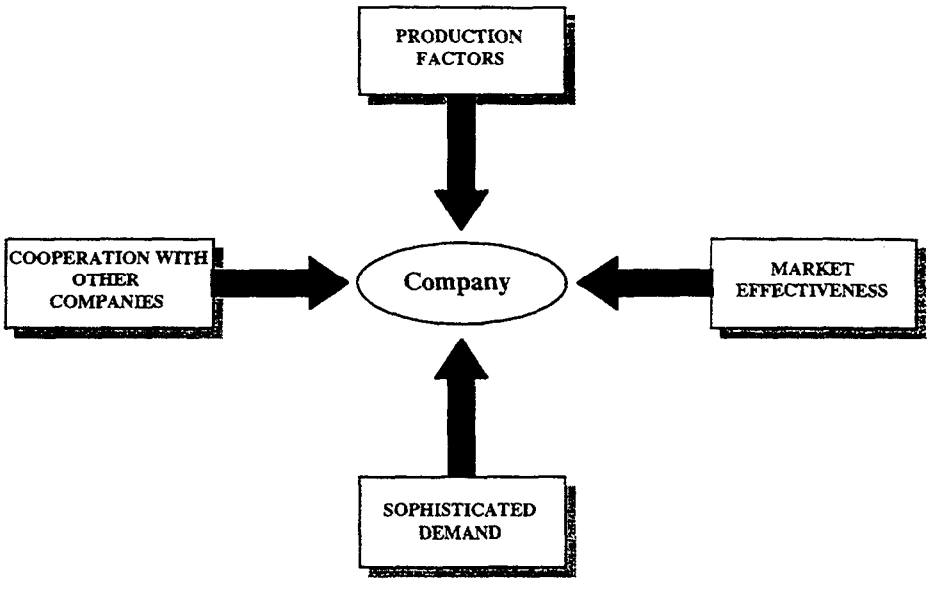

Figure 2. Porter's Diamond Before Adaptation to the Danish RAA. [Source: M. Porter, in *The Competitive Advantage of Nations* (New York: Free Press, 1990), p. 127. For the Sake of Clarity the Factors Chance and Government are Not Shown Here]

In fact, the risk of not acting may outweigh the possible mistakes.[27] Just as firms typically judge the risk of not acting to be higher than that of taking risky choices, so should government. Upholding NAC will not involve highly strategic governmental policies, and will thus seem as less of a risky venture. Some parts of innovation and technology policy will be more selective in nature and, consequently, involve higher risks.

In order to minimize the likelihood of government failure in such cases, this type of policy should be developed in a bottom-up manner, meaning that the academic, political, professional, and business communities should all be involved in the policy-making process.[28]

According to M. Teubal, policies should have life-cycles that evolve over time, just as their product life-cycle counterparts do.[29] Government policies should, Teubal argues, have a catalyzing role in which initial neutrality in policy formulation and implementation is replaced by increased selectivity over time.

Thus, neutral policies will be useful in the initial phases of the policy cycles: those aimed at preserving and updating the NAC. It should be emphasized that the neutrality in the policy approach follows from uncertainty over market failures and from different learning and innovation potentials in the heterogeneous firms, which are unpredictable. This differs from the neoclassical argument for neutrality by preventing the introduction of state-induced distortions in the market.

The purpose of neutral policy is to remedy market failures and to make firms aware of developments presently not receiving attention. Thus, in this

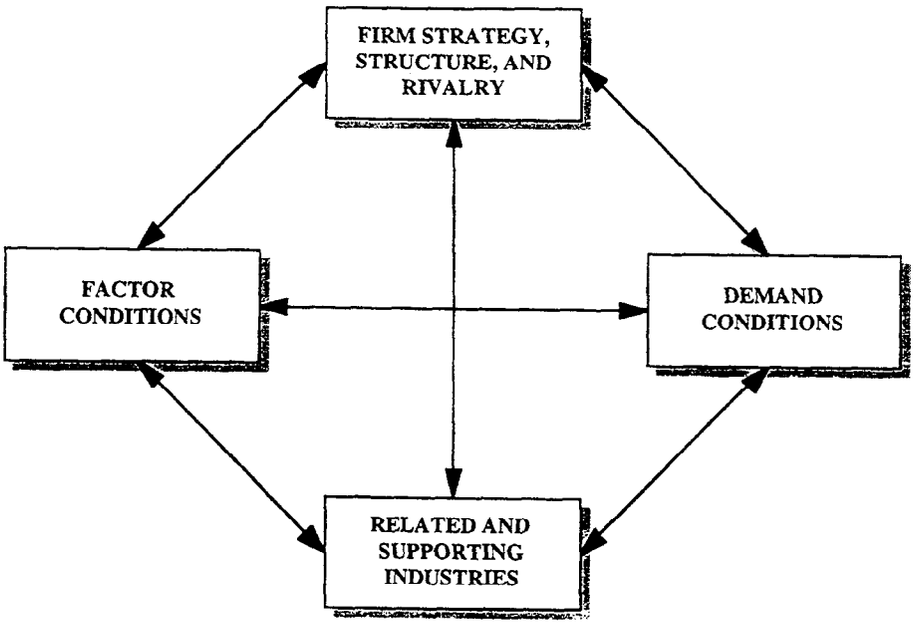

Figure 3. The Diamond After Adaptation to the Danish RAA. The Company and its Framework Conditions. [Source: Erhvervsredegorrelsen (Business Report) (Industrir- og Samordningsministeriet, Copenhagen, 1993), p. 39. For the Sake of Clarity the Factor Public Administraton and Service is not Shown Here]

stage, bottom-up policy formulation is required less since it is neutral in nature: it involves few information requirements. In addition, it is less feasible since the actors do not yet know what their true needs are. The subsequent shift in the nature of policy towards more selective issues should then follow after both the government and the other parties involved have learned about their needs.

And yet, there must remain a large neutral component in the policy, since innovation is a process and new technological developments take place all the time. Thus, in order to safeguard NAC, some part of innovation and technology policy has to be neutral in nature.

However, after the results of the neutral policies have been reviewed and the areas in which competitive advantages seem to have emerged or are likely to do so in the future have been identified, selective follow-up policies may be warranted. It is at this crucial stage in which the nature of the policies changes that information requirements increase drastically and lead to a need to involve all the relevant actors. This bottom-up procedure may have several advantages over the more traditional top-down approach:

- Governments will, by asking companies, be better informed about the true needs of business community

- Creating a dialogue is a very important part of generating national strategies that will carry broad enough consensus and political support to result in a process that may become self-reinforcing
- Interactive learning-processes between governments and businesses, among the several participating companies are stimulated. This may result in the creation of a common terminology that may often be lacking in government-business communication.

The development of innovation and technology policy in a bottom-up manner does not conclude when the initial policies have been formulated and implemented. Rather, a continuous dialogue is needed to update knowledge and enable the fine-tuning of the policies after evaluation.
Selectivity does not translate into picking winners. When more selective support follows a neutral approach in which strongholds have been identified, one can hardly speak of picking winners.

While this may seem to be an interventionist policy, the amount of support in pecuniary terms does not necessarily increase, since intervention is not aimed at exceeding the absolute minimum level required to catalyze the desired activities within the private sector.

Thus, the catalytic role of the policies is to stimulate processes that will lead to endogenous activities within the firms, activities in which the government plays an illuminating rather than subsidizing role.

What connects all of these approaches is that, in order for any innovation, strategy, and policy framework to be relevant, it must be based on a capabilities-approach.

The Danish Resource Area Analysis: Background

Denmark, a small Scandinavian welfare state with a population of about 5.2 million and GDP per capita of $26,500, has traditionally supported liberal policies and, until the 1980s, did not have many innovation and technology policies. This changed when several national programs were introduced to diffuse technology. At the beginning of the 1990s, a political consensus emerged to strengthen Danish industries to combat a high level of unemployment.[30]

In 1991, the Danish Industry and Trade Development Council (ITDC) set out to analyze eight key business areas — resource areas, not clusters.[31-33] These resource area analyses (RAAs) may be viewed as an attempt to apply a resource-based approach to national strategy formulation.

The eight resource areas selected comprise about 90% of the total Danish business sector in terms of exports and employment.

The RAAs were coordinated by the National Agency of Industry and Trade (NAIT), now called the Danish Agency for Development of Trade and Industry (DADTI). Formally, the initiative was intended:

> to establish new and updated knowledge of the general trade conditions in which Danish companies operate and develop. This knowledge will provide the basis of the Council's advice to the Danish Government on aspects of industrial policy.[34]

As a clear informal goal, however:

> The Danish resource area analyses are to be understood as an attempt to create institutional infrastructures for industrial change by the means of networking and discourse formation within the industry-policy community. The establishment of the institutions entrusted with the conduct of the analyses was in itself an attempt of erecting new policy instruments.[35]

For every resource area, an analysis was carried out by a consortium that was selected for the task by the DADTI, after it offered the project as a public tender. In order to ensure both depth of analysis and a close connection to real-life business practices, every consortium had to consist of both researchers and business consultants. Furthermore, reference groups were established within each resource area. These groups consisted of practitioners who were involved on a daily basis in the area and who commented upon progress throughout the project.

Since the analyses were finalized in 1994, it is too early to judge the success of the enterprise in developing a foundation for innovation and technology policy.

The RAA: a Resource-based Approach to National Strategy Formulation

Each RAA was conducted on the basis of an economic business approach that resembles the resource-based approach presented in this paper. The basis of the approach used in the RAAs is to view the decision-making within firms as most important to Danish international competitiveness. This differs from traditional macro-economic approaches that emphasize relative costs and factor endowments.

Apart from services, all resource areas have been defined on the demand-side as those institutions and companies that supply groups of products or services with common or similar market characteristics to end-users. This definition of areas has created problems in terms of incompatibility with existing statistical data and has forced a certain overlap between the areas. However, it was decided that the areas would be defined in a way that categorized those institutions and companies that face the same framework conditions as belonging in the same domain.

These framework conditions play an important role in the RAAs.[36] Although originally inspired by the Porter framework, the RAAs have redefined these conditions. In so doing, they have become a bridge between resource-based and environmental approaches.

Thus, framework conditions are the factors that are valuable to the firm and are not part of its internal resource-base. Despite the fact that they are part of the firm's external environment they are firm-specific, since every firm has its idiosyncratic resource-base and factors of value will vary from firm to firm.

The difficulty then lies in devising meso-level policies that are neutral enough to affect a variety of firms' framework conditions and selective

enough to have a real impact. This is in line with the report presented by the IDTC to the Danish government that is largely based on the results of the RAA and its subsequent horizontal analyses, which characterize the similarities and differences between the eight areas.[37]

It is argued in this report that policies should simultaneously be targeted towards the improvement of certain framework conditions and address the diversity between and within the resource areas. This has led IDTC to conclude that sound innovation and technology policy should be long-term in character and multi-faceted in nature.

By adopting a resource-based perspective in combination with environmental school arguments, the RAAs have illuminated the framework conditions that are important to and shared by Danish firms operating within comparable environments.

Within each resource area, the analysis has spanned from the treatment of overall conditions to issues specific to certain firms, which were mentioned by name and analyzed in regard to the durability, transparency, transferability, and replicability of their resource-bases.

As such, the RAAs can be viewed as an exercise in neutral policy formulation that has provided the basis for more selective future policymaking by the IDTC. Generally this has led the IDTC to advance future policies aimed at improving:

- (infra-) structural and framework conditions
- the cooperation between companies
- the cooperation between companies and their external environment
- the internal resource-base in the companies.

All of these items are elements of the resource-based approach to innovation and technology policy. It appears then that the IDTC has arrived at a resource-based policy framework.

This impression is strengthened by their description of the NSI, as presented on p. 62 of their report.

According to the IDTC, this figure illustrates that the central position of the knowledge infrastructure is a connective node and point of transfer of national and international technology and capabilities for companies.

This reflects the recommendations of the first horizontal analysis to emerge from the resource area analysis:[38]

- policy should not generate research projects that are state-of-the-art, since none or only few Danish companies will be able to use the knowledge that these projects will produce
- policy should only stimulate such projects in areas in which Danish industry already stands strong and has the absorptive capacity to absorb and put to good use such projects, such as medical technologies and biotechnology
- Focus on strongholds, which should be developed further in a bottom-up manner with the involvement of all the relevant actors also of the business community.

The first two conclusions agree with my approach and are arguments that a policy can only have the desired impact if and when the absorptive capacity to assimilate it is present. Thus, a policy should, besides having more applied elements, always maintain and uphold NAC.

While most policymakers and analysts agree that the traditional emphasis on diffusion-oriented policy in Denmark should continue, this focus on strongholds indicates some selectivity, in line with recommendations of an expert panel of the OECD that concluded its review of the Danish NSI.[39] While the government has been very careful in avoiding any impression of being engaged in a picking-winners contest, the RAAs have been combined with an effort to identify national strongholds. After the strongholds are identified, recommendations on how they should be preserved and sustained must be developed. However, policymakers sometimes defend strongholds for the wrong reasons. Thus:

> Key policymakers are presently more inclined than ever to devise government policies aimed at maintaining Danish positions in traditional strongholds. The logic seems to be that since we can't follow suit in emerging industries — we need to remain strong in industries where we have historically excelled.[40]

While strongholds should be defended, it is a mistake to do so merely because Denmark cannot keep up with emerging industries, implying that more neutral policies towards emerging technologies are of secondary importance.

This will in the long run decrease the NAC and reduce the strength of the NSI. In addition, the effects of a decrease in the size or rate of growth of the markets for current Danish strongholds should be considered.

The latter is not merely a hypothetical threat. The fact that Danish market shares in exports in the OECD-market have grown since 1984 seems to be a result of Danish specialization in products that were hit less hard during the recession in the end of the 1980s and beginning of the 1990s, than those in the more high-technology markets.[41]

Resource-based is not the same as SWOT

While the RAAs began as exercises of Porter-type cluster analysis, the goal of clarifying the framework conditions of the Danish business sector steered the analysis process in a resource-based direction. It seems that the researchers and representatives of the DADTI and Danish ministries do not realize this. Thus, they refer to Porter when discussing the RAAs, rather than focus on the issues that they added to SWOT analysis. That the Porter framework was modified can be illustrated with a before and after adaptation to the RAA picture of the diamond of Porter's theory of competitive advantage.

Clearly, much more than just slight modifications to Porter's framework are involved when centering the approach around a single company and its framework conditions.

Noting that Porter's analytical framework is extended to include market effectiveness and public administration and service is correct but not sufficient: it fails to capture the analytical shift from environmental to resource-based analysis that is exemplified.

Possible Problems and Unused Potential

The IDTC has initiated further initiatives and studies by appointing follow-up committees. The realization that policy itself should evolve over time has enhanced the capability for future policymaking in the Danish government. Interestingly, though, the foreword to the IDTC's 1994 report reads:

> The analyses will now enter the separate Ministries, and the government has initiated a follow-up of the analyses, on the background of which the EUR has decided not to go into a direct priority-setting of the recommendations.[42]

This, in the context of the theoretical framework outlined above, appears to be a mistake since a priority-setting exercise may result in the generation of several policy capabilities in Danish government, even when the priorities are not actualized. One reason to not set priorities is to avoid being identified with picking winners on behalf of the IDTC. However, as I have argued above, selecting and supporting strongholds is not the same as picking winners. Furthermore picking winners, no matter how unpopular its connotation, may be warranted in areas that have clearly increasing returns to scale and are "socially desirable."[43]

Another serious problem is identified by M. Kluth and J. B. Andersen:

> Having said this, it is however also our impression that a number of policy makers behind the analyses were seemingly not paying much attention to the potential embedded in creating policy networks. Thus during, and at the end, the analyses primary focus was upon the policy proposals of each report. As it is among other things stated in the foreword of each report "the purpose of the analysis is to create a coherent picture of Danish business' problems. On the basis of the analyses and its policy proposals the ITDC will in 1994 propose a forward looking industrial policy.[44]

If this is correct, it is a serious blow to the positive effects that the RAA may have in terms of building channels through which government and businesses may interact. In fact, if the IDTC will eventually not get involved in setting priorities and providing policy proposals, most of the potential embedded in the RAA may be left unused.

The RAA has shown that bottom-up policy formulation causes new problems. Besides the emerging need for different statistics, there is a more fundamental and severe difficulty, as a representative of DADTI stated during a seminar on industrial policy at Roskilde University:

> We asked the representatives of the different Danish industrial sectors what they would want us to do — in policy terms — if and when we could not change macroeconomic conditions. The answer was a long-lasting silence.

Research into the ways that firms may express their strategic needs without disclosing secrets in a situation of information asymmetry between the firm and the government is warranted. Resolution of this issue is a crucial step in the development of the resource-based approach to innovation and technology policy.

Notes

1. D. C. North, "Economic Performance Through Time," *American Economic Review*, Vol. 84, no. 3 (1994), pp. 359-368.
2. R. M. Grant, "The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation," *California Management Review*, Vol. 33, no. 3 (1991), pp. 114-134.
3. J. Barney, "Firm Resources and Sustained Competitive Advantage", *Journal of Management*, Vol. 17, no. 1, p. 102.
4. Based on Grant, *op. cit.*, pp. 124-128. Barney, *op. cit.*, describes resources that are able to sustain competitive advantages as having the following four attributes (pp. 105-112): valuable, rare, imperfectly imitable, and not having substitutes available. While the terminology is slightly different form Grant's, the two taxonomies are almost entirely compatible.
5. It is interesting that the concept of resource-base has not found its way to the center of the resource-based view. It seems a logical extension to the approach of defining a firm's resource-base as the resources and capabilities that allow it to at present or in the future to seize opportunities or neutralize competitive threats.
6. Some prefer to call it "the positioning school." H. Mintzberg, "Strategy Formation: Schools of Thought," in J. W. Frederickson (ed.), *Perspectives on Strategic Management* (New York: Harper Business, 1990), pp. 105-233.
7. M. Porter, "Towards a Dynamic Theory of strategy," *Strategic Management Journal*, Vol. 12, Winter (1991), pp. 99-100.
8. D. Teece, G. Pisano and A. Shuen, *Firm Capabilities, Resources, and the Concept of Strategy: Four Paradigms of Strategic Management, CCC Working Paper* (Berkeley, CA: University of California, 1990), p. 15. The authors describe the resource-based view as "from the inside-out," "where inside refers to inside the firm and outside refers to the business environment." The environmental school, by contrast is there referred to as having a "from the outside in" perspective.
9. Porter, *op.cit.*, pp. 107-109.
10. J. A. Black and K. B. Boal, "Strategic Resources: Traits, Configurations and Paths to Sustainable Competitive Advantage," *Strategic Management Journal*, Vol. 15 (1994), pp. 131-148.
11. J. Barney, *op.cit.*, p. 106.
12. R. R. Nelson and S. Winter, *An Evolutionary Theory of Economic Change* (Cambridge, MA: Harvard University Press, 1982).
13. G. Dosi and R. R. Nelson, "An Introduction to Evolutionary Theories in Economics," *Journal of Evolutionary Economics*, Vol. 4 (1994), pp. 153-172, and S. Metcalfe, "Evolution, Technology, Policy and Technology Management," *Prometheus*, Vol. 12, no. 1 (1994), pp. 29-35.
14. In a recent article, the link between the resource-based view and the evolutionary economic approach was illustrated in an interesting way: by its composition of authors. "Understanding Corporate Coherence: Theory and Evidence," *Journal of Economic Behavior and Organization*, Vol. 23 (1994), was thus written jointly by two founders of the resource-based approach, D. J. Teece and R. Rumelt — as well as two founders of the evolutionary approach, G. Dosi and S. Winter.
15. B. Dalum, "Export Specialization, Structural Competitiveness and National Systems of Innovation," in B. A. Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning* (London: Pinter Publishers, 1992), pp. 191-225.
16. *Review of Denmark's Science, Technology and Innovation Policies*, Examiners' Report, OECD, Paris (1994).
17. W. M. Cohen and D. A. Levinthal, "Absorptive Capacity: a New Perspective on Learning and Innovation," *Administrative Science Quarterly*, Vol. 35 (1990), p. 128.
18. *Ibid.*, p. 136. Interestingly, within the economics of technological change, the "opposite" term lock-in is applied to a situation in which economic agents after a certain amount of time select a certain technology regardless of preferences due to increasing returns. Brian Arthur has made important contributions in this area.

19. D. J. Teece, "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," *Research Policy*, Vol. 15, no. 6 (1986), p. 304.
20. B. A. Lundvall, *op. cit.* and R. R. Nelson (ed.), *National Innovation Systems: A Comparative Analysis* (Oxford: Oxford University Press, 1993).
21. Thus in Nelson, *ibid.*, R. R. Nelson and N. Rosenberg discuss in the first chapter each of the three components of NSI: innovation, system and national, but do not provide an overall definition.
22. It is tempting to view the NSI as those set of actors and institutions that are identified by firms and policymakers to be of relevance to a nations innovative capability. One could, using extensive questionnaires, attempt to map the NSIs of the different countries.
23. Furthermore, I believe that it is not the policies that deserve analytical priority, but the reasons for their coming into being and the actors affected by and making those policies. An interesting question within Wijnberg's framework would be what would happen to the Danish NSI if one day all the policies affecting innovation would be scrapped at the national, EU, and other levels.
24. M. Humbert, "Strategic Industrial Policies in a Global Industrial System," *Review of International Political Economy*, Vol. 1, no. 3 (1994), pp. 445-463.
25. P. A. David and D. Foray, "Accessing and Expanding the Science and Technology Knowledge Base," OECD, Paris (1994). 26. *Ibid.*, p. 14.
27. One should not forget that evolutionary processes always look inherently wasteful in hindsight. This does not mean, however, that we could have done better, just that optimizing is only possible in hindsight.
28. In particular, the professional component may as a "translation-device," helping the different parties articulate their needs in terms understandable to the other parties.
29. M. Teubal, *R&D and Technology Policy in NICs as Learning Processes*, unpublished paper (1994).
30. Erhvervsredegørrelsen, (Business report), Industri- og Samordningsministeriet, Copenhagen (1993 and 1994). The important issue of to what extent stimulation of industry might create jobs elsewhere goes beyond the scope of this paper.
31. The eight areas are: food products, pharmaceuticals, environment/energy, light industry, construction/housing, transport/communications, tourism/leisure time and services. The areas were selected arbitrarily in categories broad enough to avoid the impression of being engaged in a selective exercise, while not dividing them into so many fields that it would become unmanageable analytically.
32. As an indicator of the fact that there has been political consensus on the need for more active innovation and technology policy, this initiative was started under the Conservative-led government and carried on after political power shifted towards the Social Democrats in 1993. This event, if anything, boosted the importance attached to the RAA.
33. M. Kluth and J. B. Andersen, *Creating Institutional Infrastructures for Structural Change: The Case of the Danish Resource Area Analysis*, paper presented at the Annual Meeting of the European Association for Evolutionary Political Economy, Copenhagen (1994). The authors provide the interesting anecdote on p. 15 that "Initially the then Conservative Minister of Industry was opposed to the concept of cluster analyses and meant that it was left-wing politics and had a strong element of picking the winners. As a curiosity it should be mentioned that the Conservative Minister of Industry presumably changed her mind at a conference held by the Danish Engineering Society in Copenhagen 1991, where Michael Porter participated on a video-screen and had the opportunity to convince the minister that cluster analyses were not about picking winners and the opportunity to inform the minister that he served as economic advisor to the Reagan Administration!"
34. "Invitation to Pre-Qualification" in *Tender Documents, the Business Economics of Resource Areas in the Danish Business Sector — Analyses and Perspectives*," Erhvervs Udviklings Radet/Erhvervsfremme Styrelsen (ITDC/NAIT), Copenhagen (1992).
35. M. Kluth and J. B. Andersen, *op. cit.*, p. 2.
36. A translation of the more appropriate Danish term "rammebetingelser."
37. Erhvervsudviklingsradets redegørelse, Erhvervs Udviklings Radet (ITDC), Copenhagen (1994), p. 7.
38. *Ibid.*, pp. 52-66.
39. Review of Denmark's Science, Technology and Innovation Policies, *op. cit.*
40. M. Kluth and J. B. Andersen, *op. cit.*, p. 13.
41. B. Dalum, National Erhvervsudvikling og konkurrenceevne, Erhvervsfremme Styrelsen (NAIT), Copenhagen (1994).
42. Erhvervsudviklingsradets redegorelse, *op. cit.*, p. 3.
43. The latter is important since this differs between nuclear energy projects, which may not be socially desirable, and biomedical projects, which typically are socially desirable.
44. M. Kluth and J. B. Andersen, *op. cit.*, p. 17.

5

Comments on article

5.1 The background of the article

Chapters one to four explain the theoretical background of the 'Technology-in-Society', article which preceded this section. While the aim here is to put the article somewhat more in perspective, the intention is not to write an article about the article. Furthermore, the methodological issues of blending theory and empirical matter were already discussed in the introductory chapter to the thesis.
As stated earlier the aim of this PhD-thesis, is to contribute to a theoretical framework for ITP which is firmly rooted in real-life firm behaviour.
With the theoretical baggage of chapters one to three, the article's starting point, when the writing on it began in the summer of 1994, was roughly as follows:

How can we develop a framework for ITP that incorporates the systems evolutionary view at the macro-level, while linking up to where economic activity really takes place: the (micro-) firm level ?[73]

To 'answer' this question, the evolutionary/systems and RBV approaches were linked, illustrating the relevance of the synthesis by introducing the RAA, as the reader will have seen when reading the article.
While writing this synthesising article, in my mind there were four *audiences*.

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[73]See the introductory chapter to this thesis on the ever-changing nature of research questions though. As an illustration one may not that it reads in the bibliographic sketch of the article that my PhD-project involves a comparison of the Israeli and Danish innovations systems and policies. While for some short time this was accurate, I decided in favour of the present form - theoretical synthesis with one illustrative 'case', rather than a deductive method of deriving theory from a two-country comparative analysis.

Firstly, the intention was to convince researchers dealing with strategic management that their approach can usefully be extended to a higher level of aggregation. Secondly, the purpose was to persuade evolutionary economists, dealing with ITP-issues, that such a strategic management approach can be of relevance to their work. Thirdly, the aim was to show policymakers that a resource-based approach to ITP is fruitful, and in Denmark 'already being followed'. And finally, the objective was to make firms aware that a dialogue with government in which they express their needs is likely to result in policy better in line with their actual wishes. Since the article involves an eclectic approach and had this variety of 'audiences', the selection of Journal was one of the most multi-disciplinary ones in the area: Technology in Society. Since most arguments will not be familiar to at least one of the audiences, the language is kept simple; all theories are spelled out in full (though of course short), and the RAA is discussed rather extensively.

5.2 Some clarifications

After reading the fourth chapter, the reader may have noticed that there is a slightly different interpretation of the terms RBV and SWOT in the article from the one presented in the chapter. While in the chapter the RBV is seen as an integrated analysis of the inside and outside of the firm, in the article the RBV is portrayed as nearly totally focusing on internal factors, where the value of these in then determined by the complementary 'environmental models'. Also, in the article, Porter-type competitive strategy analysis is treated as the near equivalent of SWOT-analysis, which is not the case in chapter four, and further is equated with 'environmental models'.
Both issues are related to fact that at the time of writing the article I relied extensively on Barney (1991), and adopted most of his views and terminology related to the RBV. Thus he is quoted in the article for writing that there is

> *an important complementarity between environmental models of competitive advantage and the resource-based model. These environmental models help isolate those firm attributes that exploit opportunities and/or neutralize threats, and thus specify which firm attributes can be considered as resources. The resource-based model then suggests what additional characteristics that these resources must possess if they are to generate sustained competitive advantage (Barney,1991, p.106.)*

While initially useful, I have moved away from this interpretation towards the one that Collis and Montgomery (1995) provide, who view the RBV as inherently dealing with both the inside and outside.

The views don't exclude each other, but rather represent a different degree of emphasis/focus. The usage of SWOT is related to this in that I chose to 'equate' competitive strategy with SWOT, since it was the most widely applied SWOT model that by focusing on the OT-part simultaneously was **the** environmental model. Still, to avoid misunderstanding I should point out (again) that SWOT was around before competitive strategy analysis[74]. Maybe, Mintzberg's (1990) terminology is more appropriate, who distinguishes between ten schools of thought in strategic management among which the design school and the positioning school. SWOT then is associated with the design school, which treats strategy as a *conceptual* process, and has been criticised for separating strategy formulation and implementation. The positioning school, that started more or less with the work of Michael Porter treats strategy formation as an *analytical* process, and also separates thinking from acting[75].
While they are similar, and although also based on the SWOT-model, the positioning school introduced economics-related analytical tools, and emphasised on the strategies rather than how they were formulated. In doing so, it took SWOT further than were it had ever been; the reason for my equating SWOT and positioning school.

Another issue which may be in want of some clarification, is the definition of absorptive capacity, which was "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends". In a similar vain NAC is defined as "those institutions that allow firms within the NSI to recognize the value of new, external information, assimilate it, and apply it to commercial ends". What should be emphasised is that besides being able to absorb, firms need to be actively engaged in search behaviour and have 'search-capabilities'. Together the absorptive and search capabilities mount to knowing how and where to look, when to start/stop looking and how to assimilate new external information. The combination of search and absorptive capacity, is crucial to firms for building and maintaining their resource-bases which may provide them with a SCA[76].

Also, I would like to point out that the argument I make in the article that strongholds should be supported but not for 'the wrong reasons' basically is an evolutionary variety-argument. Thus while indeed strongholds should be defended, the implication that to do so merely since Denmark couldn't keep up in emerging industries does seem to imply a reluctance to remain engaged in neutral policies.

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[74]According to Spender (1992, p.6), SWOT has been around even before World War II !!
[75]As we shall see in the second article I use the term environmental school. This one, Mintzberg reserves for yet another approach that sees strategy formation as a *passive* process.
[76]These points are included in the next article.

This, in evolutionary economic terms, would reduce variety and as such may be a highly risky and counter-productive exercise!
Furthermore, the catalytic nature of ITP can also be seen in this evolutionary light, as the diffusion of new organisational routines that after adoption will start to lead a life of their own and no longer will need government intervention.
Finally, it may be useful to add that since the writing of the article a 147 pages long
report by the Ministry of Business and Industry (Erhvervsministeriet 1995) has been completed that presents an analysis of the Danish strongholds. The following criteria for a stronghold were developed:

- The area should have an exports volume above 2 billion Danish Crowns (ca. 1 % of total exports). This criterion represents the societal importance and width and stability of the area

- Denmark should have experienced a growth in its market share in the area up to 1990, either as compared to 1970 or 1980. This criterion 'measures' sustained international competitiveness.

- Denmark should be specialised in the area; i.e. The share of the area in Denmark should be higher than the share of this area in other countries.[77]

- The wages in the area in Denmark, should be above the average compared to both the national Danish average and the wages in the same area in main competing countries in the area. This criterion indicates that the area is strong not because of low wages but based on more sustainable other kinds of resources.

After applying these criteria eight areas fulfil all the above criteria and emerge as Danish strongholds. These are: the nutrition industry, wood industry, furniture industry, graphical industry, pharmaceutical manufacturers, manufacturing of building materials, iron and metals industry, and shipyards and shipbuilding.
Two related things should be noted. Firstly, the analysis identifies mainly **industries** as strongholds, a notion not fitting well with our resource-based approach to ITP.
Secondly, in the report it is made clear that while an analysis at the firm-level is necessary to provide a more complete picture it is not performed, mainly due to problems in collecting internationally comparable data.

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[77]The actual comparison was with Germany, USA, Japan, France, UK, Italy, The Netherlands, Belgium, Canada, Sweden, Finland, Norway and Australia; the countries that are part of the OECD's STAN-database.

While surely this lack of data is a correct observation[78], it seems that somehow the useful insights of the RAA are either forgotten or consciously neglected. Especially using the very industry data, that were criticised in the RAA as not providing an accurate picture, due to the heterogeneity within industries, seems difficult to grasp as an initiative under the authority of the very same Ministry. It may have been better not to present any analysis at all, than an analysis which is at 'theoretical odds' with the major ITP analysis exercise -the RAA - Denmark has done in the 1990s.

5.3 Towards the next article

The article ends with the observation that

> *Research into the ways firms express their strategic needs without disclosing secrets in a situation of information asymmetry between the firm and government is warranted. Resolution of this issue is a crucial step in the development of the resource-based approach to innovation and technology policy.*

This is one of the issues that is dealt with in the next article, which is entitled: "Problems and Prospects of Bottom-Up Policy Formulation: Towards User Defined Innovation and Technology Policy (UDITP) ?" As implied by the title, this article addresses besides presenting the merits of the resource-based approach to ITP analysis[79] more closely looks at the problems involved. It will be argued that it is useful to distinguish between an analytical and implementation stage, where the RAA can be seen as the former. Such ITP analysis needs to be complemented in the implementation phase by an approach that recognises the heterogeneity of firms as well: **User Defined Innovation and Technology Policy** (UDITP).

[78]Possible with the recent Community Innovation Surveys this incommensurability is finally changing though. In this European CIS-project 'standard' innovation surveys were done in the different EU-countries, hopefully paving the way for internationally comparable statistics on a company-level.

[79]Which are presented in more elaborate fashion in the first preceding article.

Problems and Prospects of Bottom-Up Policy Formulation: towards User Defined Innovation and Technology Policy (UDITP) ?

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Problems and Prospects of Bottom-Up Policy Formulation: Towards User Defined Innovation and Technology Policy (UDITP) ?

Abstract

In today's world, competitive firms attend to only part of the abundantly available information, by specialising and focusing on core capabilities and competencies.
As a result firms differ and, correspondingly, have a variety of different needs in terms of Innovation and Technology Policy (ITP).
Consequently, ITP should move from the industry-level to the firm-level and, where possible, involve the business community to define their own idiosyncratic needs.
A recent Danish policy analysis exercise - the Resource Area Analysis (RAA) - can be interpreted as the development of such a firm-level, Resource-Based Approach (RBA) to ITP.
After presenting the RAA, both the merits and problems of this bottom-up RBA to ITP are discussed.
Finally, it will be argued that while the RBA to ITP analysis is useful, it needs to be complemented in the implementation phase by an approach that recognises the heterogeneity of firms as well: User Defined Innovation and Technology Policy (UDITP).

Firms differ, and acknowledging this fact has implications for innovation and technology policy (ITP) analysis, as well as ITP implementation. In order to convey this message this paper proceeds as follows.
Firstly, it argues that government has a role to play in stimulating innovation at a firm-level, and discusses what this role might look like. Then, a recent Danish policy analysis exercise: the Resource Area Analysis - will illustrate that the envisaged approach is feasible in practice, while it also creates new problems. Finally, some tentative thoughts on how to proceed from ITP analysis to implementation are presented leading to the concept of User Defined Innovation and Technology Policy (UDITP).

On resources, focusing and absorptive capacity: the need for ITP

All modern economies are host to a great number of firms that each specialise in their individual product/service mix. What particular activities a company engages in, depends on the views and motives its decision-makers have regarding future developments. These, in turn, are partly a product of the experiences the firm and the people within it, have accumulated in the past. History matters, and the strategic options of today are partly constrained by the choices we made yesterday. Firms thus search locally for solutions when facing threats or opportunities, and in doing so may acquire increasingly idiosyncratic behaviours over time.
The fact that countries are made up of firms with particular historical, cultural and institutional set-ups, is one factor that leads to the development of specific patterns which change only slowly over time[80].
It has been suggested that in a small country like Denmark, 99% of new science and technology (S&T) must come from outside its borders[81].
The development of specialisation patterns, combined with this heavy dependence on externally developed S&T, creates the danger that new developments relevant to the firms, but not in their immediate search space, will be overlooked.

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[80]See B. Dalum, "Export specialization, structural competitiveness and national systems of innovation" in B. Å. Lundvall (ed.) , *National Systems of Innovation: Towards a theory of innovation and interactive learning*, (London: Pinter Publishers, 1992), pp. 191-225.
[81]See *Science, Technology and Innovation Policies: Denmark*, OECD, Paris, (1995), pp.167-168.

Firms then must besides specialising and developing their own unique profile, be able "to recognize the value of new, external information, assimilate it, and apply it to commercial ends[82]"; they must have *absorptive capacity.*
Besides this ability to absorb, firms should also be actively engaged in search behaviour and have 'search-capabilities'. Together the absorptive and search capabilities mount to knowing how, when and where to look for what types of information and when to stop searching and start assimilating new external information, which is an ongoing organisational process.
Absorptive capacity requires a certain degree of open-mindedness on behalf of the firm, particularly in order to prevent *lockout* where[83]:

> *"once a firm ceases investing in its absorptive capacity in a quickly moving field, it may never assimilate and exploit new information in that field, regardless of the value of that information"*

However, at the same time the "opposite" wisdom - don't be too open-minded and stay focused - is put forward by an emerging strategic management theory: the resource-based view of the firm.
Traditionally the questions guiding strategic management have been "What business are we in?" and "What businesses should we be in, given the competitive landscape and forecasts for futures changes?"[84].
In the resource-based view the guiding question becomes "What capabilities do we need to develop and nurture to take full advantage of those changes?"[85].

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[82]W. M. Cohen and D. A. Levinthal, "Absorptive capacity: a New Perspective on Learning and Innovation", *Administrative Science Quarterly*, Vol. 35 (1990), p. 128.
[83]*Ibid.*, p. 136.
[84]C. Long & M. Vickers-Koch, "Using Core Capabilities to Create Competitive Advantage", *Organizational Dynamics*, (1995), p.11.
[85]*Ibid.*

In the resource-based view, firms should pursue a sustainable competitive advantage[86] by developing and nurturing capabilities and resources that are rare, valuable, imperfectly imitable and have no strategically equivalent substitutes[87]. Put differently, the sustainability of the competitive advantage, is a function of four characteristics that the firm's resources and capabilities may possess to varying degrees[88]:

- durability — the rate at which the resources and capabilities underlying the Sustained Competitive Advantage (SCA) become *obsolete*;
- transparency — the degree to which the resources and capabilities behind the SCA, and the resources and capabilities required for replication, can be *identified* by competitors;
- transferability — The extent to which it is possible for competitors to *acquire* the resources and capabilities behind the SCA necessary to enter competition; and
- replicability — The extent to which competitors can *replicate internally* the resources and capabilities behind the SCA

By assuming that firms within an industry may be heterogeneous, and that this heterogeneity maybe long-lasting since the resources which are the sources of these firm differences are not perfectly mobile, the resource-based approach differs from the traditionally dominant 'competitive strategy school'. This school, which was pioneered by Michael Porter, has tended to focus on the link between firm strategy and the external opportunities and threats facing the firm. Strategy however, is "the match an organization makes between its internal resources and skills...and the opportunities and risks created by its external environment"[89].

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[86]A firm has a sustainable competitive advantage when it is "implementing a value creating strategy not simultaneously being implemented by any current or potential competitors", J. Barney, "Firm Resources and Sustained Competitive Advantage", *Journal of Management*, Vol. 17, No. 1, p.102, (1991).

[87]See J. Barney, *Op.cit.*, pp. 105-112.

[88]Based on Robert M. Grant, "The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation", *California Management Review*, Volume 33, Number 3, (1991), pp. 124 128.

[89]C.W. Hofer and D. Schendel, *Strategy Formulation. Analytic Concepts*, (St.Paul,MN:West,1978),p.12.

In the resource-based approach the value of a resource, originally defined as "anything which could be thought of as a strength of a weakness of a given firm"[90], is determined by its ability to exploit opportunities and/or neutralise threats. In other words, the resource-based approach intrinsically links an analysis of a firm's internal state of affairs with a treatment of its external environment, since the value of its resources/capabilities depend on the potential to exploit these in the market place[91]. This redirection of research efforts towards an investigation of the match between internal resources and capabilities and strategy formulation is crucial , since:

> *"in a world where customer preferences are volatile, the identity of customers is changing, and the technologies for serving customer requirements are developing rapidly, an externally focused orientation does not provide the constancy of direction to act as a secure foundation for formulating long-term strategy. When the external environment is in a state of flux, the firm itself in terms of its bundle of resources and capabilities may be on a much more stable basis on which to define its identity.*
> *Hence, a definition of the firm in terms of what it is capable of doing may offer a more durable basis for strategy than a definition based upon the needs that the business seeks to satisfy"*[92]

Resource-based and absorptive capacity-based explanations are not polar opposites in their explanation of competitiveness. Thus they both intrinsically link the inside capabilities of firms to utilise/exploit the potential in their environment, while insisting on the 'inside' as the point of departure. Rather, they both oppose the competitive strategy school by reversing its order of strategy analysis.
Thus, instead of first analysing industry attractiveness and positioning the firm within this context (outside-in perspective), the firm's strengths and weaknesses are assessed first, and placed in their 'optimal' industrial context (inside-out perspective)[93].

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[90]B. Wernerfelt, "A resource-based View of the Firm", Strategic Management Journal, Vol.5, 1984, p.172.

[91]As a result, the strategy formulation process prescribed by the resource-based approach looks quite different from the one described above that is associated with the competitive strategy school. Instead of 'jockeying for favourable positions' within an attractive industry, management's task now becomes to exploit the company's principal resources, ensure they are fully employed and exploited to the limit while building/maintaining the company's resource base

[92]R. Grant, *Contemporary Strategy Analysis: Concepts, Techniques, Applications*, (Oxford: Basil Blackwell), 1995), pp. 115-116.

[93]Inside should here be understood as inside the firm's boundaries, while outside refers to the external environment outside the firm's boundaries. The inside-out and outside-in concepts, were coined in D. Teece, G. Pisano and A. Shuen, *Firm capabilities, Resources, and the Concept of*

When firms follow a resource-based strategy, they need to focus on the development and maintenance of resources that are rare, valuable, imperfectly imitable and have no strategically equivalent substitutes[94]. This focusing inherently hinders firms to keep an entirely open mind; a resource-based strategy may cost in terms of absorptive capacity. This possible conflict between resource-based strategy and the maintenance of absorptive capacity, creates the need for government to intervene and 'remedy' this market failure. It is to the government's role then, we now turn.

Contemporary ITP; safeguarding NAC and providing good framework conditions

From the above it follows that one government ITP task is to ensure that firms uphold and maintain absorptive capacity, which may suffer in light of the resource-based strategies they (should) follow. This upholding and maintaining absorptive capacity on a national level, I have elsewhere coined ensuring good *National Absorptive Capacity* (NAC)[95].
While guarding and continuously updating NAC is a major ITP-task it should not be the only goal of contemporary policy making; simultaneously it is essential that firms are surrounded by good *framework conditions.* These are factors that lay outside the firm's boundaries, but are requisite in its production process to sustain competitiveness[96].
While this article argues that a firm's internal factors deserve analytical priority, this does not diminish the importance of the factors outside the firm's boundaries. Especially framework conditions, which are outside the firm's boundaries but need to be 'internalised' to exploit market opportunities and neutralise threats, need consideration.
In Denmark[97], the government has recently adopted as its main ITP-goal to secure good framework conditions for Danish companies.

Strategy: Four Paradigms of Strategic Management, CCC Working Paper (University of California at Berkeley, 1990), p. 15.

94See J. Barney, *Op.cit.*, pp. 105-112.

95For more on the concept of National Absorptive Capacity and its relation to recent discussions on National Systems of Innovation, see P.Wegloop, "Linking Firm Strategy and Government Action: Towards a Resource-based Perspective on Innovation and Technology Policy, *Technology in Society*, Vol.17, No. 4, 1995, pp.413-428.

96Elsewhere I have defined framework conditions as "the factors that are valuable to the firm and are not part of its internal resource-base. Despite the fact that they are part of the firm's external environment they are firm-specific, since every firm has its idiosyncratic resource-base, and factors of value will vary from firm to firm." Wegloop, *Op.cit.*, p. 423.

97Denmark is a small Scandinavian welfare state with a population of around 5,2 million people and GDP per capita of ca. 26.500$. When I refer here to Danish ITP this is a translation mainly of the term *Erhvervspolitik*, which literally means Business Policy. This policy has two main goals in Denmark: 1) stimulating globalisation of Danish companies; 2) stimulating innovation within Danish companies. By focusing on Erhvervspolitik as ITP, I hence regard part of its scope, although it is definitely its most extensive part.

These were rather broadly defined as "those factors that are of importance to the competitiveness and development potential of firms"; but do not include macro-economic conditions and the well-functioning of the labour-market. They include: production factors (e.g. human resources and technological capabilities), cooperation with other companies, sophisticated demand and the effectiveness of the market[98].
In the next section I will start to describe how a recent Danish policy analysis exercise - the Resource Area Analysis - has "mapped" these framework conditions.

Background for the RAA: Porter's Diamond

In order to get an understanding of the condition of Danish industry and its framework conditions, it was decided in 1991 that the Danish Industry and Trade Development Council (ITDC) should initiate a series of analyses of eight key Danish business areas - the so-called resource areas - including[99]:

- food products
- pharmaceutical/health
- environment/energy
- light industry
- construction/housing
- transport/communications
- tourism/leisure
- services.

Apart from the area of services all resource areas have been defined from the "demand-side" on the basis of its unique features, as those institutions and companies that supply groups of products (services) with common/similar market characteristics to the end-users[100].
This Resource Area Analysis (RAA) originated in Michael Porter's, by now famous, "cluster approach"[101].

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[98]See *Erhvervsredegørelse* , Ministeriet for Erhvervspolitisk Samordning, (1993), pp.38-39, Also see *Erhvervsredegørelse* , Industri- og SamordningsMinisteriet, (1994), p.9 and, *Erhvervsredegørelse* , Erhvervsministeriet(1995), p.15.

[99]The areas were selected arbitrarily, broad enough to avoid the impression of being engaged in a selective exercise while not dividing into so many fields that it would become unmanageable analytically.

[100]This definition of areas has created problems in terms of incompatibility with existing statistical data, and forced a certain overlap between the areas to be acceptable. However, it was decided - realising this would cause statistical difficulties - as necessary to define the areas in a way which regarded those institutions and companies that face the same *framework conditions* as belonging to the same domain.

101.See Michael E. Porter, *The Competitive Advantage of Nations*, (London:MacMillan,1990).

In Porter's approach the central questions to be addressed in order to assess national competitiveness are:

> *"Why are firms based in a particular nation able to create and sustain competitive advantage against the world's best competitors in a particular field? And why is one nation often the home for so many of an industry's world leaders?*[102]*"*

Essential in Porter's approach is that ultimately:

> *"Firms, not nations, compete in international markets. We must understand how firms create and sustain competitive advantage in order to explain what role the nation plays in the process"*[103].

When discussing the determinants of national competitive advantage however, Porter switches the level of analysis and addresses the issue of:

> *"Why does a nation achieve international success in a* ***particular industry****?*[104]*"*

This then results in a framework where four factors are the main determinants in promoting or impeding the creation of a competitive advantage:

1. Factor conditions
2. Demand conditions
3. Related and supporting industries
4. Firm strategy, structure and rivalry.

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102 *Ibid.*, p. 1.
103 *Ibid.*, p. 33.
104 *Ibid.*, p. 71, my emphasis.

Graphically this is then represented in a *diamond* which looks as follows:

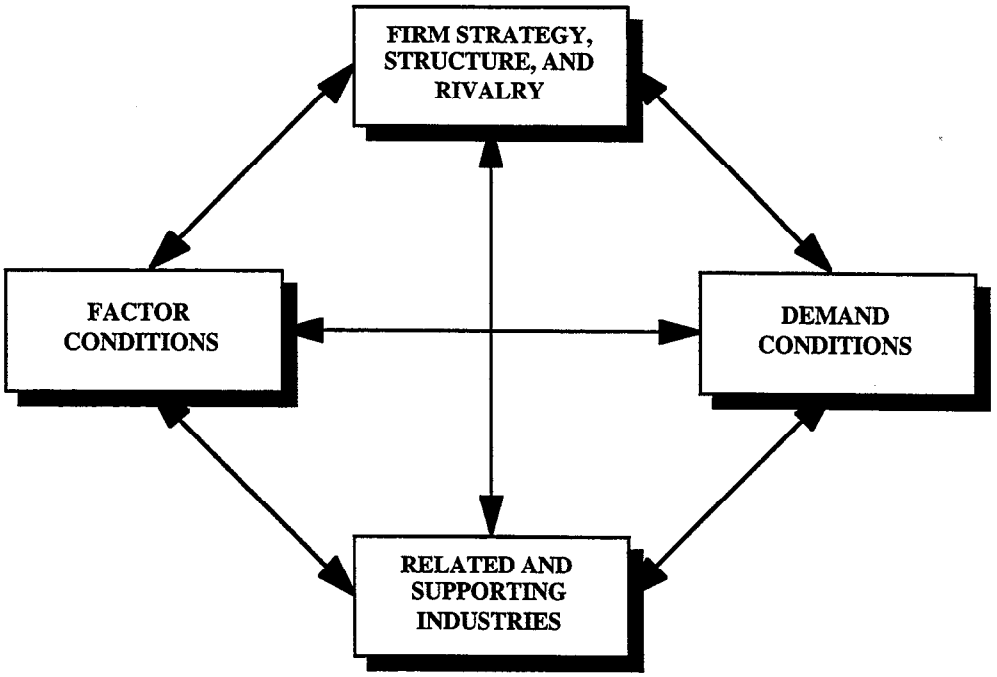

Figure 1. Porter's Diamond[105]

The fact that Porter analyses national competitive advantage at an *industry-level*, after first explaining it is the firm which stands at the basis of it, is not surprising. Thus, he has been one of the founding fathers of that school in industrial economics/strategic management, which regards the external environment - the industry - as the most decisive factor in a firm's strategy formulation.

The RAA changes direction: From Porter-inspired to Resource-based ITP

The RAAs eight areas cover around 90% of the total Danish business sector in terms of exports and employment, and it was from the outset the intention that the analytical exercise should eventually form the basis for future ITP[106]. The RAA was coordinated by the National Agency of Industry and Trade (recently named the Danish Agency for Development of Trade and Industry (DADTI)). So far it has led to a report for each of the eight areas and some horizontal analyses treating problems common to the different areas.

105*Ibid.*, p. 72.

106.For much more on the RAA, see Wegloop, *Op.cit,* and Michael Kluth and Jørn B. Andersen, "Creating Institutional Infrastructures for Structural Change: The Case of the Danish Resource Area Analysis ", presented at the Annual Meeting of the European Association for Evolutionary Political Economy, Copenhagen (1994).

In every resource area the analysis was carried out by a consortium which was selected for the task by the DADTI after offering the project as a public tender. To ensure both depth of analysis and a close connection to real-life business practice, every consortium had to consist of both researchers as well as business consultants.
Furthermore, reference groups were set up within each resource area, consisting of practitioners involved on a daily basis in the area, who commented upon progress throughout the project. Just to illustrate in the case of the analysis on the Pharmaceuticals/Health area this reference group consisted of 10 of the largest Danish firms in the area as well one person from each of the following institutions: the Danish Agency for Development of Trade and Industry (chairman), the National Health Services, the Danish Society of Surgical and Medical Suppliers , the Economic Council of the Labour Movement, the Danish Medical Device Association, The Association of Danish Pharmaceutical Industry, The Association of County Councils in Denmark (which through its procurement is one the largest user/buyer of medical technology/devices), and the Danish Center for Technical Aids for Rehabilitation and Education.
When we look at the analytical framework of the RAA its name - while given for political reasons[107] - seems to fit perfectly.
Thus, while the RAA has started out being inspired by Porter, it has over time moved towards a macro-version of the resource-based approach to strategic management.
Firms were from the outset treated as heterogeneous, and consequently the RAA was undertaken at a firm-level, rather than at the industry-level.
Thus, within each resource area, the analysis spanned from the treatment of overall conditions facing all firms, to issues specific to certain firms, which were analysed in regard to the durability, transparency, transferability and replicability of their resource-bases[108].

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[107]The name Resource Area Analysis was chosen for political reasons, mainly in order to avoid the source of inspiration: Porter's cluster analysis. The reason for this was that the Minister of Industry at the time, who was placed right of centre on the political arena, only in 1991 was convinced by Porter himself that cluster-analysis should not be regarded as left-wing politics. This took place at a conference in Copenhagen, where Porter stated that he was an advisor to the (hardly left-wing) Reagan administration. See Michael Kluth and Jørn B. Andersen, *Ibid.*
[108]Although this specific terminology was not used.

By viewing the single company as the unit of analysis the RAA has modified Porter's diamond to the following figure:

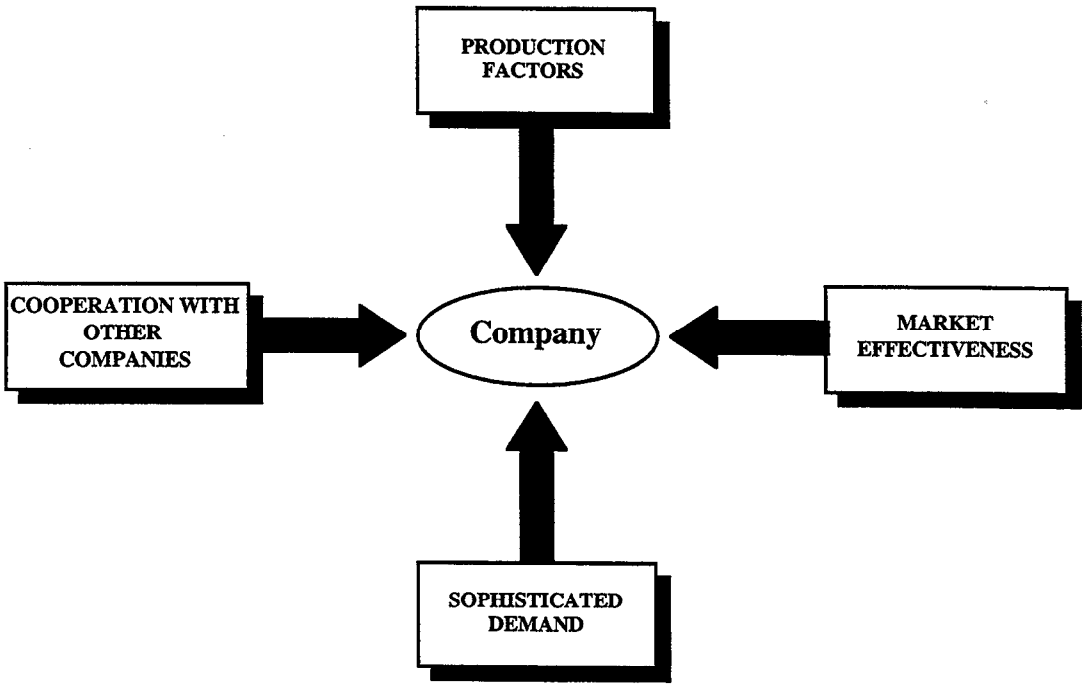

Figure 2. The Diamond After Adaptation to the Danish RAA The company and its Framework Conditions[109]

It is clearly the firm which stands at the centre of analysis, and the factors surrounding it - the framework conditions - are on a lower level of aggregation than in Porters diamond. Consequently, it becomes crucial to analyse how the single company views the role of ITP, and what problems /solutions it has to offer.

[109]Source: *Erhvervsredegørrelse* 1993, p. 39. (For the sake of clarity the factor Public Administration and Service is not shown here)

The need for bottom-up ITP formulation

In order to assure a realistic portrayal of how the single Danish company views ITP and its framework conditions, the RAA has from the outset been based on a dialogue with the various relevant actors in each of the resource areas[110].
Such a bottom-up policy formulation process, may have the following advantages[111]:

- Government will, by asking companies, be better informed about the *true needs* of the business community;

Thus:

> *"we may say that policy in its early stages should be largely regarded as a succession of experiments which the Government Agency in charge undertakes in order to eventually configure a menu of policy choices closer reflecting "needs" i.e. reflecting both the structure of the recipient population; its routines; and implications of this for fulfilling policy objectives. The upshot is ...that policy has a cycle in the same way as any radical product innovation has one.[112]"*

And,

- Interactive learning-processes between government and businesses, among the several participating companies are stimulated. This may result in the creation of a common terminology that may often be lacking in government-business communication.

110This fits well with the Minister of Industry's, Mimi Jakobsen, statement that the aim of the Ministry should be to **please** rather thank **pick** the winners (Ugebrevet Mandag Morgen, nr.9, 4.marts, 1996).
111Wegloop, *Op.cit.*, pp. 421-422.
112M. Teubal, "A catalytic and Evolutionary Approach to Horizontal Technology Policies, Mimeo, IDPG-STEP, (1995), p.7.

These interactive learning processes will be crucial in the "infant-phase" of the ITP-cycle which:

> *"..is essentially an experimental phase with a clear predominance of search activities of various kinds devoted both to enhanced understanding on the one hand and generation of good SDA (Socially Desirable Activities[113]) projects on the other. This search includes intense interaction between the firms being promoted on the one hand and policy makers on the other[114].*

Over time, all the parties involved in the ITP process will learn, and

> *"The result of this interaction and learning will be a reduction in the "target uncertainty" facing policy makers i.e. a clarification of the effective targets of policy. This will also be accompanied by a clarification of the effective means for achieving these targets.[115]"*

Importantly, this learning on behalf of both government and ITP-beneficiaries may have positive financial spill-overs, since:

> *"...a real budget constraint does not exist at the infant stage since there is a generalized absence of good projects and of associated search and management\organizational routines.*
> *Thus essentially any "good" project ....must receive government support. This is not the case at the mature phase where a constant flow of privately profitable projects continuously emerges from the system such that, at infant stage levels of support, there would be "excess demand" for government funds (rather than excess supply) i.e. the budget constraint would be effective[116].*

The results of the RAA have so far led the ITDC to conclude that future ITP should be directed at the improvement of[117]:

- (infra-) structural and *framework* conditions
- cooperation between companies
- cooperation between companies and their external environment
- the internal "resource-base" in the companies

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[113]Socially desirable activities (SDAs) must of course be defined within their relevant context. Undisputed SDAs may be medical technologies, whereas nuclear technologies come to mind as an activity which will not enjoy consensus as an SDA.

[114]*Ibid.*, p.33

[115]*Ibid.*, p.31

[116]M. Teubal, "R&D and Technology Policy at NIC's as Learning Processes", Mimeo, (1995), p.8.

[117]See *Erhvervsudviklingsrådets Redegørelse*, Erhvervs Udviklings Rådet (ITDC), (1994).

Of the 232 concrete policy initiatives that were suggested in the eight initial analyses, 98 can be considered implemented, 35 partially implemented, 43 are still being processed and 'only 50' so far have been rejected (6 are unaccounted for)[118].
In the ongoing follow-up to the RAA, a reference group, consisting of officials, users, producers, trade/industry associations and other relevant parties, functions as the coordinator which selects the critical issues deserving attention in the resource area. These reference groups have the power to set up working groups, presently 22 in number, which also are composed of various actors. These working groups discuss/suggest concrete policy initiatives, which are transferred to the Ministry of Industry who may implement them or not.
How collective learning may take place in a positive manner was illustrated in the working group on medical technology and disposables. Here dialogue exposed the fact that Danish companies are unsatisfied with the research environment surrounding plastic material which is of prime importance to some leading disposables producers. Interaction also provided the useful detailed information though, that part of the desired strengthening of their research area is taking place in the framework of the Danish materials technology development program (MUP). Thus, merely increasing support for research in plastic materials, may to some extent be a duplication of effort and consequently waste of resources. Instead, it may now be possible to assess what part of the research/capabilities in plastic research are not covered by MUP, and deserve special attention to form the basis of more relevant ands less costly policy initiatives.
Perhaps even more interesting, is the case of a policy initiative which was suggested in the Pharmaceutical/Health area which was **not** implemented.
This involved the establishment of a database which would provide a good statistical overview of the products, suppliers, users, etc., in the area of medical technology. However in the working group it became clear that the intended user of such a database - the Danish companies - would not make use of it. This, since they already had access to most of the information through other channels and because the data represent sensitive information which is of importance to their competitiveness, and hence its disclosure may pose a problem.
In my view, it is unlikely that the Ministry would have realised it would be 'wasting money', in any other process that did not directly involve the companies themselves.
While these only are two examples, they illustrate clearly how collective learning might function to prevent wasteful projects and 'steer' policy in 'the right direction'.

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118 *Dialog med ressourceområderne*, Erhvervsministeriet, February, 1996.

The problem of information disclosure mentioned above links us quite naturally to the next section, as it is one of the four problems that may be associated with bottom-up analysis which are discussed below.

New practice, new problems?

In this section I will discuss four problems that may affect the quality of interaction between government and firms participating in bottom-up ITP analysis.
Two kinds of such potential procedural problems should be addressed. Firstly, there is a risk that the analyses lack in realism when it really matters. Secondly, even when one would accept that exercises like the RAA generate new ITP insights, it is not certain this will lead to new types of actual ITP initiatives. Four main factors may cause these complications:

- Information asymmetry

The idea of asking firms about their actual needs in principle must be a good one. However, the question arises of whether firms are willing to unfold their true strategic needs to those carrying out the analysis.
Unfortunately, one may expect that the more important and strategic a factor is for the firm's sustained competitiveness, the less willing its management will be to disclose it[119].
This, since the risk that competitors will benefit from this disclosure may outweigh the expected benefits of the eventual ITP which will be based on this disclosure. Old habits die hard, and in a recent analysis of nearly 4000 Danish companies only ca. 20% declared they were satisfied with Danish national ITP[120]. So, why should it get better next time? Moreover, competitors typically will react faster upon strategic knowledge than ministries can, due to institutional constraints. This also may cause a reluctance by firms to disclose relevant information.

119One could for instance easily understand an unwillingness on the part of management to disclose a weakness in a technological capability, which it expects will become of increasing importance in future competition.
120.From *Erhvervslivets syn på den offentlige sektor: undersøgelse af den offentlige service til erhvervslivet*, Finansministeriet, Industri- og Samordningsministeriet og Kommunernes Landsforening, June, (1994).

- articulation of needs

Furthermore, one may expect that even when firms are willing to disclose strategic information, they will have problems doing so.
Thus, understanding of the most crucial threats and opportunities facing firms, may be expected to involve a large tacit component especially as they are probably of a highly company-specific nature.
Furthermore, firms are not the only type of organisation that develop its own profile, but ministries may also be expected to acquire their own idiosyncratic culture. As a result it is likely that firms and ministries may have anything but a common terminology on the truly central issues. In fact it may be that the more crucial a need is to the firm, the more likely it is that it will not be able to articulate it in for government officials understandable terms[121].

- The who is involved problem?

It is for obvious reasons impossible to involve all firms and organisations in a bottom-up policy exercise.
The problem is that the needs of those that are taking part in the ITP formulation process, are not necessarily representative for those not involved. In the RAA one gets the impression that it was typically the larger Danish firms that have been involved in policy analysis/formulation. But it must be feared that they have different needs than the small and medium-sized enterprises[122]. This problem may even cast doubt on the extent to which the bottom-up approach in practice differs from the industry-level analysis.
Finally, there may be a problem called:

- The aggregation problem

When eventually the findings have to be translated into policy initiatives, some form of aggregating the data is obviously called for. However, aggregation will cause problems due to the very company-specific input to the bottom-up analysis. Conversely, one may fear that when omitting all the factors complicating aggregation, one will arrive at the same result as the less costly and time-consuming industry-level cluster analysis would have provided.

121.Realising all this, it is not surprising that a DADTI representative commented that the business community came up with no response when asked what ITP should be followed (apart from ensuring good macro-economic conditions). Noted by a representative of DADTI at a seminar on Industrial Policy at Roskilde University, 10/11/1993.
122.This since they typically can spend fewer resources than larger firms on the search process for relevant support schemes.

Having shown why bottom-up ITP analysis may be useful, and what new procedural problems it may cause, it is now time to present a tentative framework for ITP implementation: user-defined ITP - UDITP.

Towards User-defined ITP (UDITP) ?

So far I have argued for the usefulness of a resource-based approach to ITP analysis, and discussed some inherent procedural problems this approach may have. In this final section some tentative thoughts on how to overcome these difficulties are presented, by outlining the contours of an ITP-framework which complements the bottom-up analytical procedure described above; ITP implementation through open-ended user-defined innovation policies/schemes.

The process I envisage is the following. By means of a bottom-up approach, initial framework condition-level policies are developed; i.e. an RAA-like analysis is performed in order to generate ideas.

Hereafter, government may define a large set of policies aimed at improving both the absorptive capacity and framework conditions of firms.

In order to assure that the policies also can function as mind-opener and not merely reinforce contemporary firm behaviour, some schemes will have to be based on items not touched upon in the bottom-up process. This is a crucial issue, since one may expect that firms over time develop traditions and repertoires that may limit their room for manoeuvring/expressing themselves, in the interactive policy formulation process. As such a bottom-up process relying solely on interaction with firms at the micro-level may be limited in recognising potential and threats at the meso-level. In the Danish case, the participation of trade/industry associations, research institutes and other interest groups in the bottom-up process may partly eliminate this problem, but one should not forget that also such meso-level actors are bound by their historical background.

Therefore, policy schemes should be developed in a number that exceeds the immediate needs as expressed by the interest groups in the bottom-up formulation process. These in turn should be implemented by allowing each firm to select only a limited number of the total amount of available policy schemes. Thus firms may be allowed to use a specified budget or number of policy schemes, where they themselves decide on how/when to use what initiative. There is precedence for such a type of policy arrangement in Denmark, with the *clip-ticket-scheme* (*klippekortordning*) for entrepreneurs. This scheme allows starting entrepreneurs, after having accepted their business-plan by one of 120 state-approved 'supervisors', to receive up to 70% (max. 30.000 Dkr.) of the costs related to the building up of competencies/capabilities covered.

This sum of money may be used on consultancy or education, and it is the entrepreneur who decides how to distribute the support[123].
After formulating policy schemes in this way, the results of how/which support schemes are used should be by continuously analysed, providing government officials with an impression of needs in the business community that could not be revealed in the bottom-up process. Rather, these are discovered through the "revealed preference" exposed by the firms in the ways they use the schemes.
Upon feedback from the users of the support schemes and by drawing on the experiences of what schemes were used and why, government then may continuously fine-tune these schemes. These then, are user-defined in the sense that the pattern of how they are used determines the character of their future profile.
While RAA-type analysis may be said to create a market-place (forum for the exchange of) for policy ideas, user-defined implementation creates a corresponding market for the actual policy initiatives.
By enabling companies to choose the most appropriate support schemes one may expect that the efficiency on the 'market for support schemes' may increase due to ongoing demand-induced changes. Combined with the present concentration of financial support schemes in The Danish Fund for Industrial Growth (Vækstfonden)[124] - which through enabling the administrators to choose the better projects may increase efficiency on the supply-side - a *real market mechanism* for support schemes may be created by introducing UDITP.
In my view, taking seriously the problem of policymaking in a world populated by heterogeneous firms, calls for this type of approach.
Furthermore, this way of implementing ITP may help overcome some of the above problems related to bottom-up ITP formulation.
Firstly, the UDITP process allows firms to disclose what they need in policy terms without actually saying it but rather by *revealing preferences*. This may help diminishing the *information asymmetry problem*, and facilitate easier *articulation of needs*; possibly even exposing some needs the firms themselves were not aware of existed.
Furthermore, the *who is involved problem* is not present in this phase, since all the firms using the schemes are per definition involved.

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[123]See *Midtvejsevaluering af Iværksætterklippekortet*, PLS Consult, Erhvervsfremme Styrelsen, Erhvervsministeriet, May, (1995) . In this report that concerns a halfway evaluation of this klippekort-scheme, it was shown that so far the entrepreneurs decided to use ca. 71% of total support on counselling/consultancy and 29% on education/courses. Also see Oplæg *til en ny iværksætterpolitik*, Betænkning fra Iværksætterudvalget, nr.1304, Erhvervsministeriet, 1996.

[124]This process has been started to avoid unnecessary bureaucracy, and prevent inconsistencies between various policy schemes. The fund, concentrates the supply of financial support schemes, while emphasising risk-sharing in order to ensure the commitment of the companies involved, and prevent application for projects companies would anyway launch. The fund offers loans that have to be paid back by the companies only in the case of success.

As such, one can test if indeed the results of the RAA-type analysis were representative, and if not one can adjust the policy schemes.
Finally, the *aggregation problem* is diminished since less aggregation is needed (there is a multitude of schemes), while analysing the patterns of how and which firms use the schemes is possible also in more quantitative terms.
The combination of an RAA/UDITP approach fits with the idea of an ITP policy life cycle as advocated by Teubal referred to above.
Teubal emphasises neutral policy support schemes[125] in the initial phases of ITP, that will, over time, be replaced by more targeted and strategic schemes after interactive learning has clarified goals, needs and tools.
Here a slightly different angle is chosen, where a more clear distinction between ITP analysis and implementation is made.
Thus, by drawing on the Danish RAA experience we may consider the ITP analysis part as a neutral analytical exercise which will generate broadly defined ITP schemes. In the implementation stage, through ongoing dialogue and the adoption of a UDITP approach, the schemes are then fine-tuned and in doing so become increasingly selective.
One interesting way of looking at this UDITP, and deserving future research is viewing ITP as providing firms with **options** to execute certain behaviours in the future.
Thus firms are enabled to develop their own portfolio of ITP-schemes which can be viewed as options on possible future innovation avenues. A core argument in the option approach to financial management[126] is that managers need to consider the value of keeping their options open, taking future opportunities represented by the present options into account[127].
This, besides relating to UDITP, fits very well with the NAC-concept, where government's task can be restated as ensuring firms are in the possession of a variety of options to be executed if desired/relevant when windows of opportunities emerge.
Firm heterogeneity commands bottom-up customer-driven ITP analysis and implementation. This paper has been a first small step towards the development of a framework which may guide such an approach. May it not be the last !

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[125]Neutral here means non-discriminatory, i.e. not favouring one project over another due to its specific kind of industry, branch, product class or technological area. For more on this see Teubal, M. "Neutrality in Science Policy: The Development of Sophisticated Technology in Israel", *Minerva* 21, (summer), pp. 172-87, (1984).

[126]See Avinash K. Dixit and Robert S. Pindyck, "The Options Approach to Capital Investment", *Harvard Business Review*, May-June 1995.

[127]The option approach is currently also being related to issues of technological entrepreneurship. See Dan J. Gelvan, *Technological Entrepreneurship and the Utilization of External Resources: Realizing the Potential*, PhD dissertation, Roskilde University, June 1995.

Acknowledgements: The author would like to thank Dan Gelvan, Jesper Jespersen, Jan Karlin, Frank Skov Kristensen, Jon Sundbo, Morris Teubal and two anonymous referees for helpful comments on earlier versions of this paper. Any remaining errors or misinterpretations are of course solely my responsibility.

6

Comments on article

6.1 The background of the article

> To bridge the gap between good, theory-based conclusions and their accomplishment in the real political arena requires more than a knowledge of S&T (Science and Technology) policy. It requires a talent for everyday battle in the policy arena. That makes the job of a policy maker a skill, a particular kind of tacit knowledge that gives limitations to any policy analysis.
>
> S. Radosevic (1991, p.258)

It is probably needless to say that the background of the article is the first article. What I should add is that while my original intention was to focus nearly completely on the problems and prospects of the approach developed in the first article, it became clear while writing, that the main content of the first paper had to be restated. This since the approach I suggested there was new, and it can not be expected that readers can appreciate the criticism/fine-tuning of an approach that they are not familiar with in the first place. The article was written with the very diverse readership of the Journal called *Science and Public Policy* in mind, a multi-disciplinary journal to which the article has been submitted. The language and way of expressing myself should reflect this, in that the article was written so that it would make sense to scientists as well as policymakers and businessmen. In that sense the article at first sight may to some seem slightly less 'scientific' than the first article. However, as will have become clear to the reader from the introduction to this dissertation, in my view good science is conveying the message in the most understandable and comprehensive way whenever this is possible. As such the fact that the language in the article is simple is in my view a plus and contributes to the scientific value of it, rather than diminish it. While I perhaps do enter some areas which by some will be considered to belong to political science, I should stress again that my views are those of an economist looking at the policy area[128].

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128 For a political scientist's view on Danish technology policy see Munk Christiansen, 1988.

What this means in practice is that my article aims at generating descriptive theory, and discuss some of its potential pros and cons, while not claiming that the ideas can be implemented without further modifications in practice. Put differently, the article (and dissertation as a whole) would probably be a good starting point for a political scientist who is interested in the rationale/direction of contemporary ITP. In my view, this PhD-thesis as such has succeeded in raising the relevant issues (which is the aim of descriptive theory, see Ch.1), and invites the political science community to help trying to answer the difficult issues ahead.
In looking at ITP as an economist, I follow in the footsteps of people like Ergas and Justman and Teubal.
Henry Ergas, in his classic 1986 article "Does Technology Policy Matter?", distinguished between three groups of countries with different modes of ITP[129].

mission-oriented - Countries with a technology policy that "chooses" major projects of national importance, as the means to "ensure" economic growth (though also other interests like sovereignty may play a role).

diffusion-oriented - Countries with a technology policy that aims at oriented providing the firms with the capabilities to adapt and implement new technologies when available[130].

Japan - *A group of its own,* combining both mission- and diffusion-oriented elements in its technology policy.

Denmark has traditionally, always belonged to the group of diffusion-oriented countries. With its highly skilled labour force and relative small size this seems a strategy prescribed by external circumstances. However, in light of the resource-based approach to ITP, one may claim that this diffusion-oriented approach should dominate over the "outdated" mission-oriented type ITP in all countries. Thus upholding and sustaining NAC, a critical aspect of the RBA to ITP, could be translated as being diffusion-oriented ITP. Furthermore, by adopting an 'inside-out' perspective and basing national strategy formulation to a large extent on the prevalent internal strengths and weaknesses, no longer does it seem to make sense to pursue missions that aim at radically new technologies developed in isolation from the existing industrial structure.

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[129]See Ch 3.1 for a discussion on the interchangeable use of the terms ITP and technology policy.
[130]In the article, Ergas made another important distinction, namely between ***shifting*** and ***deepening***. Shifting involves the transfer of resources from old to new uses, whereas deepening involves improving their productivity in existing uses. Roughly one may say that diffusion-oriented countries (e.g. Germany) specialise in deepening, whereas mission-oriented countries (e.g. the USA) in shifting.

It should be noted though that in recent years especially environmental affairs are gaining status as objectives worthy of a major public combat/endeavour. And ITP aimed at achieving environmental goals may remind very much of mission-oriented policies. However,

> *....there is a fundamental difference between older mission-oriented projects, for example nuclear, defence, and aerospace programmes, and new projects to support environmentally sustainable development.*
> *The older projects developed radically new technologies through government procurement projects that were largely isolated from the rest of the economy, though they frequently affected the structure of related industries and could lead to new spin-off technologies that had wide-spread effects on sectors. In contrast, mission-oriented environmental projects will need to combine procurement with many other policies in order to have pervasive effects on the entire structure of production and consumption within an economy. The pervasive character of new mission-oriented projects to meet environmental goals calls for a systemic approach to policy.(Arundel and Soete, 1993, p.50)*

Arundel and Soete have summarised the key features/differences of old versus new types of mission-oriented policies in the following table.

Table 6.1: Old Versus New types of Mission-oriented Projects

Old: Defence, Nuclear and Aerospace	New: Environmental Technologies
• The mission is defined in terms of the number of technical achievements with little regard to their economic feasibility	• The mission is defined in terms of economically feasible technical solutions to particular environmental problems.
• The goals and the direction of technological development are defined in advance by a small group of experts	• The direction of technical change is influenced by a wide range of actors including government, private firms and consumer groups
• Centralized control within a government administration	• Decentralized control with a large number of involved agents
• Diffusion of the results outside the core of participants is of minor importance or actively discouraged	• Diffusion of the results is a central goal and is actively encouraged
• Limited to a small group of firms that can participate owing to the emphasis on a small number of radical technologies	• An emphasis on the incrementalist development of both radical and incremental innovations in order to permit a large number of firms to participate
• Self-contained projects with little need for complementary policies and scant attention paid to coherence.	• Complementary policies vital for success and close attention paid to coherence with other goals

Source: Arundel and Soete, 1993, p.51

Clearly, the new mission-oriented projects involve strong diffusion-related elements, and each element in the table fits with the RBA to ITP. In fact we may claim that the new mission-oriented projects have as one their main missions to diffuse socially desirable technologies, indicating the blurring of boundaries between mission- and diffusion-oriented policies.
Justman and Teubal, who have written extensively on ITP from an economic perspective, distinguish between three levels of ITP (1990). While the framework in this 1990 article is static rather than dynamic, their taxonomy is useful in relation to the article. Thus they distinguish (Justman and Teubal, 1990, pp60-65) between the macroeconomic, current support and strategic level of ITP. Let us shortly describe each.

- **The macroeconomic level**

This ITP-level consists of three areas itself

1. **Macroeconomic policy** - This area may include short-term economic (e.g. low inflation) and non-economic objectives (e.g. defence), as well as long-term economic objectives (e.g. capital accumulation)

2. **Assuring a favourable environment for business**

3. **Macro strategic decisions** - This area deals mainly with the trade-offs between long-term economic and non-economic objectives (such as equality)

It may to some seem strange to include macroeconomic policy as an ITP-level. However, as Smith has pointed out (1991, p.267)

> *The innovation activity of firms responds to a wide range of policy measures, from the general macroeconomic stance to such areas as contract law and accounting regulations; the problem is to investigate whether these arenas of policy can be integrated with innovation objectives in a consistent way.*

It is in this sense, that the macroeconomic policy level of ITP should be regarded; namely, as how macroeconomic can/should look in order to be integrated with innovation objectives.

- **The current support level**

This is the ITP-level typically associated with microeconomic correction of market failure, and involves broad-based (sometimes neutral[131]) functional support in areas such as technology adoption, mobility and retraining, and support for entrepreneurship

- **The strategic level**

This level, thus Justman and Teubal, aims at assisting the markets in making appropriate strategic decisions in terms of which routes to growth are to be followed. Information requirements are obviously high, and this presupposes a high degree of policy integration and coordination. Rather than market failures, the rationale for ITP at this level are strategic failures, which are both more difficult to identify and more difficult to remedy.
It is very interesting to note that Teubal has stated, that these levels to some extent correspond to phases in ITP, when adopting a more explicitly dynamic approach[132]. Relating to the Danish experience described in the article we may divide it into three phases.

- Studies The RAA (the analysis)
- Decisions Policy formulation
- Operations Policy implementation

These then in turn can be related to the ITP-levels described above, where studies would be at the macroeconomic level, decisions at the current support and operations at the strategic level.
Furthermore, we may interpret the NAC-concept to be at the current support level, while targeted initiatives that come out after an RAA-type user-defined policy formulation process are at the strategic level.
In my view refining the Justman and Teubal taxonomy, and placing it a more dynamic setting, in combination with the RBA to ITP is a very useful area for future research.

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[131]The concept of neutrality is defined as (Justman and Teubal, 1990, p.58) "support for particular activities such as R&D and technology diffusion, without any explicit preference given to economic branch or sector". Besides neutrality Justman and Teubal suggest two further ITP approaches: Market stimulation and simulation, and the selective strategic approach.
[132]Personal communication.

6.2 Clarifications and some short elaborations

While I believe most of the article does not warrant clarification, especially after reading the preceding one, it may be useful to clarify the definition of framework conditions. These were in the first article defined as

> *the factors that are valuable to the firm and are not part of its internal resource-base. Despite the fact that they are part of the firm's external environment they are firm-specific, since every firm has its idiosyncratic resource-base, and factors of value will vary from firm to firm.*

In a way this definition wass related to a discussion of the boundary of the firm. Thus what I am basically arguing is that due to firm heterogeneity, firm boundaries also are firm-specific. As such the framework conditions, which may be considered the factors relevant for competitiveness which lay beyond the firm's boundaries also are firm-specific[133]. Therefore in the present article, framework conditions are defined as

> *factors that lay outside the firm's boundaries, but are requisite in its production process to sustain competitiveness*

The two 'different' definitions thus complement each other, and the change in definition should not be seen as a correction of the first definition.
Another issue which may not need clarification, but rather some short elaboration, is the option approach touched upon in the end of the paper. Thus it was argued, that ITP may be seen as providing firms with options to execute certain behaviours in the future. And it was argued that

> *A core argument in the option approach to financial management is that managers need to consider the value of keeping their options open, taking future opportunities represented by the present options into account.*

Let me shortly elaborate on the options approach to financial management. As argued by Dixit and Pindyck (1995), the traditional approach to assess if an investment is worth undertaking is as follows:

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[133] A similar argument would be that while people/businesses with access to the internet in principle have the same framework condition, their different background and interest will lead them to idiosyncratic usage patterns implying a personal 'meaning' of what internet really is to each and everyone of us.

1. Calculate the present value of the expected stream of cash that the investment will generate;

2. Calculate the present value of the expected stream of expenditures required to undertake the project;

3. Determine the net present value (NPV), which is the difference between the expected stream of cash and expenditures.

The basic decision rule is that only when the NPV is above zero, the project should be undertaken. According to Dixit and Pindyck, this model which over the years has been refined and turned into a sophisticated tool, is fundamentally flawed. This, since it regards investments

- either as reversible,

- or if/when irreversible, it treats the investment opportunity as a now-or-never proposition

These assumptions are however not realistic for most real-life investments, which are irreversible, and capable of being delayed. What the option approach offers is a way of dealing with this, by suggesting that

> *..the simple NPV rule must be modified: Instead of just being positive, the present value of the expected stream of cash must exceed the cost of the project by an amount equal to the value of keeping the investment option alive.(Dixit and Pindyck (1995, p.106)*

This approach which attributes value to **not** exercising an option, indeed

> *..fits very well with the NAC-concept, where government's task can be restated as ensuring firms are in the possession of a variety of options to be executed if desired/relevant when windows of opportunities emerge.*

Especially if Cohen and Levinthal (1994) are right in arguing that absorptive capacity besides enabling the exploitation of new extramural knowledge, also facilitates a more accurate prediction of future technological advances, it seems useful to link the two approaches.

As a final 'addition' to the article, a short story on a recent conference will be presented here. In the summer of 1995 a conference called Innovationskraft (Innovation Power/Strength) 2000 was held, which can be said to be the first occasion in Denmark where the separate concept 'innovation policy' was formally placed 'on the map'.
Until then, it has been a part of 'erhvervspolitik', which best is translated as business policy. The conference was jointly organised by the ministry of business and industry and Monday Morning's Strategic Forum[134].
In the report presented at the conference (Kristiansen and Lindholm, 1995), a case is made for the need for specific policies that deal with innovation - ITP[135]. However, it is argued, business policy has during the 1990s focused on the creation of good framework conditions, and in doing so moved away from the single company. As such a gap has been created with no policies existing to deal with company-specific innovation related issues, a fact reinforced by a tendency of research policy (coordinated by the ministry of research) to increasingly focuses on narrow R&D-related programmes[136].
Now the reader will notice the attempt to link the discussion of framework conditions with company-specific innovation issues. Furthermore, in line with our framework, (see also Chapter 3), in the report great emphasis is placed on the coordinating role of innovation policy, and also the emphasis on learning, absorptive capacity, competencies and human resources are fully in accordance with the framework of this thesis[137]. This is illustrated in figure 6.1 below, which was presented in the conclusion of the report and where innovation policy[138] is portrayed a new, autonomous area of policymaking.

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[134]The latter is a group of researchers mostly linked to the Copenhagen Business School, that through a weekly newsletter and several special reports act as a kind of consultancy/think-tank on issues pertaining to Denmark's long-term economic success. They also were the main responsible for the background report that was part of the most recent OECD evaluation of the Danish Science Technology and Innovation system (OECD, 1995).

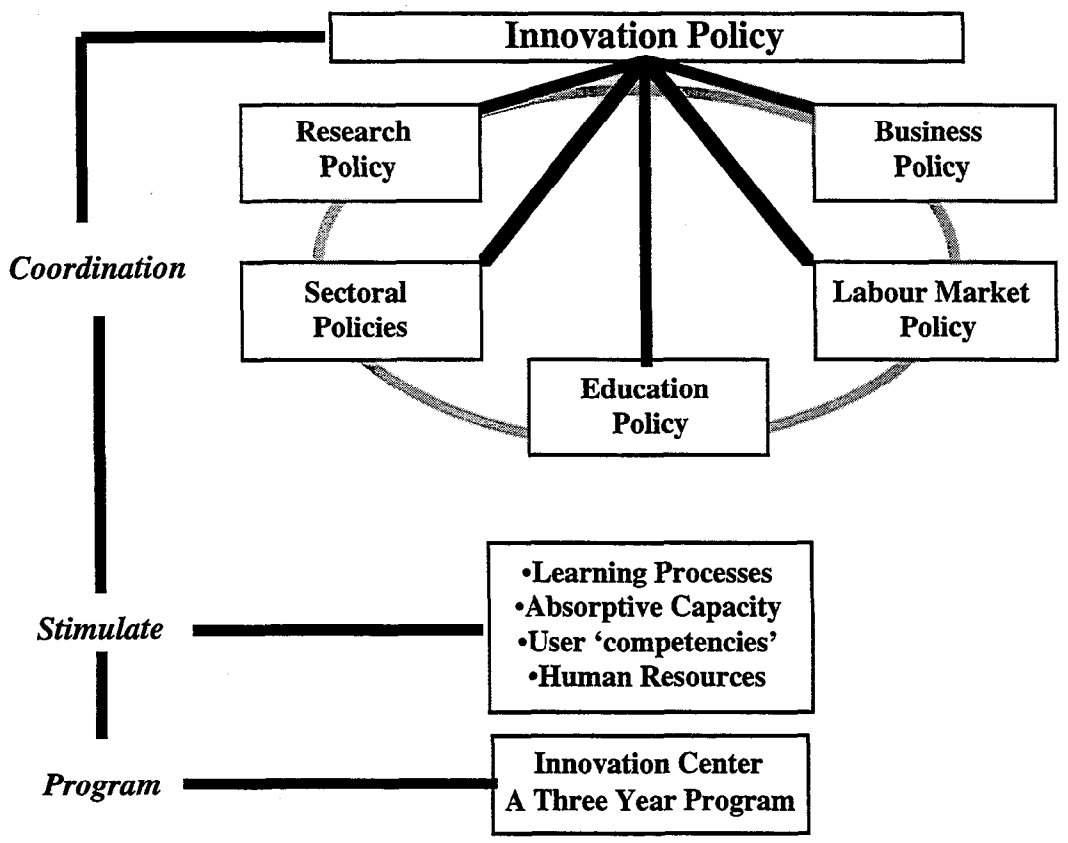
[135]This argument is mainly based on the results of studies initiated by the ITDC and DADTI that have shown that only ca. 50% of Danish industry can be called 'innovative' (Christensen and Kristensen, 1994/5). Another major argument of the report is the need to change the innovation culture in Denmark, and create a more entrepreneurial spirit in the Danish population. The Danish cultural traits of conflict avoidance and a tendency to prefer being employed rather than self-employed are in the report considered factors hindering an innovation-friendly culture, Similar observations were made in OECD, (1995).

[136]Which at best benefits the SME-dominated Danish business community indirectly, through externalities, spin-offs and the like, but only is of direct relevance to a small group of 'big players'. According to Christensen and Kristensen 1995, the research and technology-intensive companies constitute around 16% of the Danish business community.

[137]The establishment of an innovation centre, which should function as a centre of excellence in the area is thought important to visualise the increased priority innovation has/should have as part of Danish business (policy).

[138]It should be noted here that for present purposes I assume that innovation policy and ITP are the same.

Figure 6.1



Source: Kristiansen and Lindholm, 1995, p.73

ITP, as illustrated in the figure, should involve coordination, stimulation and a program. While the report mentions that coordination is necessary to ensure that the innovation potential embedded in other policy areas is exploited, it 'forgets' the opposite which is no less important; a prevention of conflicting policies which may lead to counter-productive results.
In my view the framework presented in the article can be helpful to complement the analysis by Monday Mornings Strategic Forum. Thus while in principle most of their ideas are in accordance with the framework in the article, the analysis lacks a clear linkage mechanism between the policies dealing with framework conditions, and those aimed at the single firm (and its absorptive capacity).
I believe the UDITP framework can help out here, once it is realised that the ITP-analysis should be broad and resource-based, while the implementation should be firm-specific, but that it is the *firms themselves* which should at that stage set the agenda.

Viewing the issues at hand this way enables us to treat ITP-analysis as part of more overall business policy, while in the implementation indeed it may become a separate area[139].

6.3 Towards the next article

While in my view the article provides considerable insight into the theoretical rationale for UDITP and a RBA to ITP, it does so at a somewhat abstract high level of aggregation. Therefore, in the next article, the approach is described within a specific area: the medical industry. It doing so, it will also be shown that technology assessment, which so far has been neglected in both papers, also has a role to play in contemporary ITP.

[139]That indeed innovation policy can be analysed within the framework of overall business policy was illustrated well in the 1995 business report (Erhvervsredegørelse) of the ministry of business and industry, which for the first time included a whole chapter on innovation, research and the technological servicenet.

LOOKING AT MEDICAL TECHNOLOGY ASSESSMENT THROUGH INNOVATION-EYEGLASSES

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Abstract

Health care technology is a policy issue, and medical technology assessment should be an input to its formulation. With MTA focusing on efficacy/effectiveness and cost-containement, innovation aspects have been neglected. The article considers implications for MTA of treating health care technology as an innovation and technology policy issue.

> It is time to rethink health care technology assessment. The options are many. It's your move.
>
> Goodman, (1992, p.352)

About three years ago, in an article where he argued that it was time to recast the field of medical technology assessment (MTA)[140], the above provocative sentence concluded Goodman's appeal to rethink MTA.
It's *your* move, it reads. Now, it does not say who "your" refers to. Fortunately, since this allows even outsiders like me - an economist dealing with questions of technological innovation - to take up the challenge, and try and make a contribution to the debate.
Goodman's main point was that what is needed is a clear definition of the research agenda of MTA, and a clarification of how comprehensive it should be. In the present article it is argued that for MTA to have relevance for technological innovation in the health care industry, it is essential that a broad very comprehensive approach is adopted.
When looking at the debate on MTA of the last few years, as someone who looks through *innovation-eyeglasses*, one gets the impression that such a comprehensive approach has typically not been followed. While technology and its diffusion stand at the heart of the MTA debate, the focus clearly is on controlling technological development and containing health care expenditures. This is not surprising, since:

> *Technology assessment in health care was introduced as an activity with two objectives; on the one hand, to speed the diffusion and use of medical technologies with proven safety, efficacy, and effectiveness to ensure broad and equitable access to the technology; and on the other hand, to monitor technologies that have not yet been scientifically assessed whose policy implications are not yet fully understood so that potentially harmful, useless, or less effective technologies can be phased out and replaced (Banta & Jonsson, 1994, p.290)*

[140] In this article I use the term medical technology assessment (MTA), and don't consider it to be any different from the concept used by Goodman (14), health care technology assessment.

While these two objectives probably deserve center stage in MTA, it is argued here that when a third objective is added - the **stimulation** of innovation in medical industry - MTA needs to be broadened and adopt a comprehensive approach.
This third objective might have to be added, since it is no longer possible to clearly seperate the institutions and analyses dealing with respectively the control and stimulation of technological development.
The National Board of Health in Denmark, has for several years argued, that MTA should become a *way of thinking* (Sunhedsstyrelsen, 1984;1994), in both daily incremental decisions as well as the more long-term planning/political ones.
As argued by Koch (1995), this way of thinking has in MTA typically relied on quantitative approaches, with a particular focus upon existing technologies after they have been introduced into practice, and presented a problem.
Incorporating the innovation objective, will be shown to necessitate a conceptual shift in this way of thinking, towards a more qualitative, broader and normative approach. But, I am getting ahead of my story.

New conceptions of technological change

The creation of new products, processes and services - innovation -, has gained interest in both academia and politics over the last few years. In particular the relationship between technological innovation, and the competitiveness of firms, regions and nations has attracted a great deal of attention. In the same vain as MTA provides input to the health policy debate, ITP analysis has served to provide a rationale and explore different directions in ITP.
Within economics, the renewed interest in technological innovation has led to new conceptualizations of contemporary ITP analysis. Let me briefly explain why.
Starting in the 1980s and taking off for real in the 1990s, the economics of technological change/innovation opened the black box called "technology", for economic research. In doing so, the realization came about that:

> *Technological change is often equated either with certain hardware, or with specific production processes; this is a mistake. Technological change is, in its development and application, fundamentally a social process, not an event, and should be viewed not in static but in dynamic terms. (OECD, 1988, p.9)*

This is in strong contrast with traditional economic thinking, in which technology was perceived as dropping "like manna from heaven" on the economy. This perception enabled static analysis, and the treatment of technological change as events, rather than as a process.
Based on these conceptions the *market-failure-case* for technology policy was developed, where it was argued that government involvement was called for in instances in which markets failed, due to indivisibilities, uncertainty and externalities (Arrow, 1962). In this, neoclassical, world view:

> *...the problem of technology policy appears as the identification and adoption of superior economic equilibria, defined in terms of an appropriate economic surplus criteria. Left to itself, the market mechanism will generally fail to produce the best possible allocation of resources to the development and application of technology: the source of the inefficiency resting in inappropriate incentive mechanisms or in an imperfect distribution of information across economic agents. Firms always do the best they can but, for whatever reasons, the constraints they face are the wrong ones. To change incentives becomes the central policy option, a way of thinking best summarized as the theory of the* ***optimizing policy maker*** *(my emphasis). Such a policy maker seeks to maximize social welfare in the context of individual agents who seek to maximize their personal welfare, where social and private welfare are out of step defines the arena of policy choice. The favourite metaphor here is of the policy maker as a fully-informed social planner who can identify and implement optima. (Metcalfe, 1995, p. 417)*

The newer economic theories of innovation/technological change, have criticized market failure analysis, emphasizing the need to analyze the institutional framework surrounding technology policy, and raising doubts about the implicit assumption, that the market is more efficient in allocating resources to innovation\technology development, than any other mechanism (Teubal, 1995).
More generally, the neoclassical framework of economic analysis, has been criticized for focusing on equilibrium and state, rather than process and change (Metcalfe, 1995).
However, while the criticism of the neoclassical market failure approach spread rapidly, the efforts at proposing an alternative policy framework were less successful.

Thus:

> *although the pace of reform within the framework of structural adjustment strategies continues, a major obstacle now starting to emerge is the lack of rules of the game for the promotion of technological development (Chabbal and Guinet, 1993, p.ix)*

This is not surprising, since developing new rules of the game has become a more complicated task in the world view associated with the economics of innovation; an evolutionary world, populated by heterogeneous economic agents that are only boundedly rational, learn over time, and in which technological change is a cumulative, endogenous process. Here "only God knows what policy truly would be optimal" (25,128), and there:

> *is no longer a role for the optimizing policy maker. Uncertainty, ill-defined choice sets and bounded rationality put the policy maker in exactly the same position as the institutions which policy seeks to influence(23Metcalfe, 1995,,pp.447-448).*

And,

> *The shift in perspective is important. It involves abandonment of the traditional normative goal of trying to define an "optimum" and the institutional structure that will achieve it, and an acceptance of the more modest objectives of identifying problems and possible improvements (Nelson and Winter, 1982, p.366)*

Rather than optimizing, the policy maker adapts, and the most central aspect of ITP becomes stimulating learning and creativity throughout the economy (Dalum, Johnson and Lundvall, 1992).

Towards a bottom-up ITP approach

Summarizing, one may say that contemporary ITP and its analysis are complicated by two insights that have emerged from the new theoretical perspective:

- ITP policymakers are not optimizers;
- ITP recipients consist of very heterogeneous group of firms, that have changing needs and goals

One approach, to tackle these two issues is starting to emerge, both in theory and in practice; bottom-up ITP analysis where all the relevant actors - academic, political, professional as well as from the business community are involved (Teubal, 1995). This approach may be attributed three main advantages (Wegloop, 1995):

- Policymakers will, by asking companies, be better informed about the *true needs* of the business community;

- Creating a dialogue is a very important part of generating national strategies that will carry broad enough consensus and political support to result in a process that may become self-reinforcing;

- Interactive learning-processes between government and businesses, among the several participating companies are stimulated.

Over time, all the parties involved in the ITP-analysis process will learn, and

> *The result of this interaction and learning will be a reduction in the "target uncertainty" facing policy makers i.e. a clarification of the effective targets of policy. This will also be accompanied by a clarification of the effective means for achieving these targets. (Teubal, 1995, p.3)*

Thus, the acknowledgement that firms as well as their needs in ITP terms differ, has led to an involvement of the companies to help identify those idiosyncratic needs, and tendency towards a consensus-seeking form of decision-making. This broadening, has strengthened the role of the need for technology assessment (TA)[141] as an input to the ITP debate. Thus:

> *Since technological innovation is an evolutionary process whose effects are subject to the approval of society at large, governments need to deal with questions relating to the broader integration of technological change. Economic considerations alone are no longer sufficient for the complex calculations of social costs and benefits...From this perspective, government policy is today at the crossroads....The new approach should be broader - not simply based on "market failure" - and involve experimentation with new institutional structures and arrangements.....*

[141] When I hereafter use the term TA, this refers to technology assessment in general outside the field of medical technologies. More on the difference between TA and MTA below.

A society needs to have mechanisms through which it can formulate decisions regarding the nature, acceptability and diffusion of technologies. Technology assessments, both public and private, are one such mechanism.(OECD, 1988, pp.122-124)

TA and ITP: two sides of the same coin ?

The Sundqvist report, from which the above citation is adopted, ended with the following recommendation:

Our starting point was that technological change is a social process. From that follows the need for a broad-based consensus about the impact of new technologies on the social fabric, both at the national and the international level. We therefore recommend the further development of various forms of technology assess-ment which should be a continuing process and in which elected legislatures should equip themselves to play an active and informed though not exclusive role. The basic aim should be to provide information to those concerned, to promote and partici-pate in a constructive public debate in a wide circle of institutions, thereby strengthening the democratic process through increased public understanding of, and involvement in, the process of change.(OECD, 1988, p.25)

However, despite the recognition in this OECD-report from 1988, that TA and ITP analysis should be closely linked, the two fields have to date remained rather isolated from each other. This is not surprising, since there has during the last decades been an overall tendency, to separate the activities **promoting** science and technology from those that **control** and **regulate** them (24). And, traditionally TA - and in particular MTA - has been associated with controlling and regulating technology, while ITP analysis has focused on how to stimulate technological change. However, as outlined above, the realization has emerged within the ITP debate that technological change is a social process, introducing the need for TA as an input to its considerations.
At the same time within the TA community a realization is starting to emerge, that its role should change. Thus, the emerging approach called Constructive Technology Assessment[142] (CTA), suggests that time has come to undo the two-track approach to stimulation and control of technological change.

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142 The approach took off in the 80s and increasingly is gaining momentum and recognition. Its main advocate since the mid-80s has been the Netherlands Organisation for Technology Assessment (NOTA) which in June 1994 changed its name to Rathenau Institute. Starting point for CTA are the assumptions that it is in practice possible to steer technology, whereby broadening of technology development often (but not always!) is desirable so that the quality of the technologies can be

Promotion and control activities need to go hand in hand it is argued, since technology and its effects are co-produced. Or, technology is "a social process which, by meeting real or imagined needs, changes those needs even as it is changed by them" (Soete, 1995, p.40). Consequently:

> *realistic strategies for managing technology in society...must consider impacts already during the development of the technology, involve users and other impacted communities and contain an element of societal learning in how to co-produce technology and its impacts(Misa, Rip and Schot, p.5).*

Both ITP analysis, as well as TA then, seem to be moving towards a broadening of perspectives. However, the situation is still far from ideal. Thus, ITP analysis typically still tends to neglect TA-aspects, and it will take time before this will change. Secondly, and most important for the readers of this journal, unlike general TA, MTA seems not (yet) to be moving towards a constructive approach.
Before elaborating on the latter, I will in the following section briefly present a recent Danish ITP analysis, in the area of Pharmaceuticals/Health. It illustrates how bottom-up ITP analysis might work in practice, and that in this case the TA aspects were realized but treated inadequately.

A real life bottom-up ITP analysis

In 1991 it was decided that the Danish Industry and Trade Development Council (ITDC) should initiate a series of perspective analyses of eight key Danish business areas - the so-called resource areas (RAs). This Resource Area Analysis (RAA) covered around 90% of Danish business in terms of exports and employment, and it was from the outset the intention that the analytical exercise should eventually form the basis for future ITP[143]. One of the eight[144] areas in the RAA was the Pharmaceuticals/Health sector in Denmark.
This RA was defined as "the network of companies, customers and other institutions that deliver goods and services to the health-sector (Erhvervsfremme styrelsen, 1993, p.20)" The area has traditionally been a Danish stronghold, and a number of Danish companies are world-leaders in the niches in which they operate[145].

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improved by the interactive learning taking place due to this broadening. See (Jelsma, Rip & van Os, 1995).
143.For more on the RAA, see Wegloop, 1995, and Kluth and Andersen, 1994.
144.The eight areas are: food products, pharmaceutical/health, environment/energy, light industry, construction/housing, transport/communications, tourism/leisure time and services.
145These include amongst others Radiometer (Blood Gas Analyzer), Novo Nordisk (Insulin) and Oticon (Hearing Aids). Coloplast (disposables). For more on this see Lotz, 1993.

While Denmark's export share of total world exports has for several years now circled around 1%, within this area the export shares of total world exports are, in those niches, typically much higher as illustrated in Table 1.

Table 1. Danish exports in selected areas compared with world exports, Year 1993, (current prices)[146]

	Exports				
	Total ($ millions)	Medicinal, pharmaceutical products ($ thousands)	Electro-medical equipment ($ thousands)	Medical instruments, ($ thousands)	Hearing, orthopaedic aids ($ thousands)
Total World	3634614	51502879	4353461	12946902	3908015
Denmark	36707	#1877450	#102516	#297462	#174270
Danish share of World total (%)	1,0	3,6	2,4	2,3	4,5
World exports per capita in $	656	9	1	2	1
Danish exports per capita in $	7074	362	20	57	34

The analysis focused on that part of the RA which can be classified as its core, at least in terms of its contribution to export, namely pharmaceuticals and (electro-) medical equipment. Table 2 shows the shares in terms of exports, turnover and employment of these core areas.

[146]The data for the table are adopted from United Nations, (1995). The Standard international trade classification (SITC) categories used are: SITC 541: medicinal pharmaceutical products, SITC-7741:Electro-medical equipment (excluding radiology equipment), SITC 872: medical isntruments (not elsewhere specficied) and finally SITC 8996 hearing,orthopaedic aids. For the calculations I used a 1993 world population of 5544 million, and 5,189 million for Denmark, based on UNited Nations , (1995). Data marked with # are estimates.

Table 2. Turnover, Exports and Employment in the Danish Pharmaceutical & Health Resource Area, Year 1990, (current prices)

	Turnover		Exports		Employment	
	Danish Kr. (Millions)	% of total	Danish Kr. (Millions)	% of total	Number of employees	% of total
Whole Resource Area	34224	100	13549	100	37138	100
Pharmaceuticals	11822	34,5	9192	68,3	10986	29,6
Medical non-electrical equipment	2281	6,7	1523	11,3	3756	10,1
Electro-medical equipment	1217	3,6	739	5,5	2417	6,5
Total of these Core Areas: Pharmaceuticals & Electro-medical equipment	15320	44,8	11454	85,1	17519	46,2
Rest of Resource Area	18904	55,2	2005	14,9	19979	53,8

Source: Erhvervsfremme Styrelsen, 1993, p.45

Throughout the report that resulted from the analysis a combination of historical analysis, discussion of future scenarios and cases from real-life are included. Clear distinctions were made from the start between the four major groups within the RA which were treated separately:

- pharmaceuticals
- electro-medical equipment
- rehabilitation equipment
- disposables.

Organization of the analysis

A consortium consisting of persons from consultancy firm Price Waterhouse/IKO, the Danish Hospital Institute (DHI)[147], and researchers from the Business School in Copenhagen, was responsible for the project on the Pharmaceuticals/Health RA.
In order to secure a bottom-up procedure, a reference group was set up that consisted of representatives from 10 of the largest Danish firms in the area as well one person from each of the following institutions: the Danish Agency for Development of Trade and Industry (chairman), the National Health Services, the Danish Society of Surgical and Medical Suppliers , the Economic Council of the Labour Movement, the Danish Medical Device Association, The Association of Danish Pharmaceutical Industry, The Association of County Councils in Denmark, and the Danish Center for Technical Aids for Rehabilitation and Education.

Main developments within the RA[148]

Overall the RA is expected to face moderate growth, with the possible exception of rehabilitation equipment, which is expected to enjoy high growth. The increase in the number of elderly people, who will typically be used to high standards of living and have relatively high purchasing power, is expected to contribute positively to the prospects of the RA. Furthermore the intensifying international attention for the handicapped is expected to do the same. On the other hand, most national health systems (in the developed countries) are under revision, and emphasize the need for savings and more value for money. Also there appear to be two opposing trends towards both centralization and decentralization. The first development is expected to take place in particular in order to reduce costs, while the latter is a likely consequence of new technologies that allow more and better ambulatory treatment. Finally, new private markets are expected to develop as a result of partial deregulation and privatization in the health care sector.
All this is expected to lead to growing competition, with only new high-quality products able to sustain high profit margins while "me-too" products will go down in price. Research and development is expected to become increasingly multi-disciplinary and costly, which will favor large companies that can reap the benefits of scale economies. While scale economies have traditionally been important in the pharmaceuticals area, they are thus now expected to become more central in for instance the area of disposables - in particular with increasing international standardization taking place.

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[147]For a description of the DHI, see Danneskiold-Samsøe, 1991.
[148]This is based on Erhvervsfremme styreslen, 1993,pp.128-148).

The competitive environment is due to standardization becoming more transparent, and competitive parameters like price, distribution, marketing and service will become increasingly important.

Outcome of the RA: succes, or unused potential ?

While the concrete ITP initiatives that came out of the exercise are not of core interest in this paper, it should be said that some of these have emerged such as the foundation of a Danish R&D center for rehabilitation equipment. What the RA has done in analytical terms, is novel to ITP analysis. Thus while it has been *common wisdom* to analyze competitiveness on the level of the industry, in the RAA it is the single company which stands at the center of analysis. In doing so, it has addressed the heterogeneous population ITP faces, and taken seriously cultural, historical and institutional factors. While it would take us to far to address the implications of this for actual ITP implementation, it is clear that what is at stake is a major conceptual change. While the Pharmaceuticals/Health RA has meant an important step forward in terms of addressing heterogeneity in the health care industry/sector, it has missed the opportunity to use the forum engaged in the exercise to perform some form of CTA. Thus, in the working paper that accompanies the final report on the technological changes that are taking place in the sector it reads[149]:

> *A real* futures study *of probable technological developments, or possible impacts on Danish industry or the Danish health system was not undertaken. Such an analysis could though in certain technological areas be a useful tool in strategic planning, both for the single company as well as for the national health system (Erhvervsfremme styrelsen, 1993, p.55).*

In my view it is unfortunate that such a study was not included as well, in particular since the forum engaged in the analysis described above would be very useful for a Constructive Medical Technology Assessment (CMTA) exercise.
Above, it has been argued that TA and ITP analysis are, or should be, two sides of the same coin. This should also be the case in the medical/health area, so that now it is time to discuss what such an approach could/should look like.

[149]This paper contains appendices to the final report on: international developments in the health care sector, the structure and financing of the health system in several countries, expected technological changes and finally a section on MTA and health economic analysis.

Towards Constructive Medical Resource Assessment (CMRA) ?

Medical Technology Assessment has, at least in Denmark, been largely decoupled from TA activities concerned with other technological areas. Thus, while The Danish Board of Technology has been the main institution carrying out TA and its promotion in Denmark[150], the National Board of Health has since 1982 been formally responsible for MTA.
Also, TA and MTA have adopted different approaches. Thus, while TA has traditionally followed a more qualitative approach, MTA has, as stated above, relied on more quantitative approaches. Furthermore, MTA has even more so than TA focused on the assessment of already existing technologies, after they present a problem, and in doing so stressed its role as a *watchdog*, rather than *stimulator* for new technologies.
Now the latter criticism should be somewhat qualified. Thus, for instance, in 1990 the DHI performed a *proactive* MTA of biosensors in the health sector. In the report coming out of the analysis (Jørgensen,1990), three main approaches to "analyzing the future" that are of relevance to the stimulation and control of medical (technological) innovation were distinguished, which are portrayed in Figure 1.

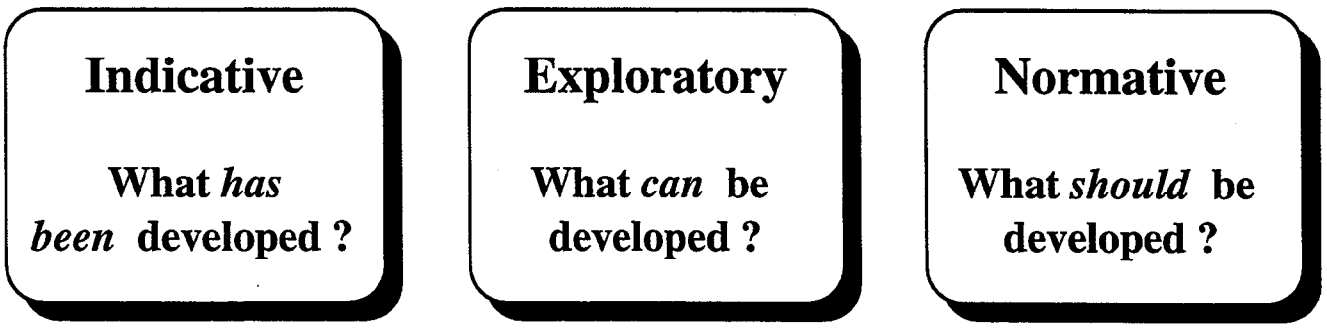

Figure 1. Approaches to "Analyzing the Future"

[150]This institute has in the summer of 1995 changed name from teknologinævnet to teknologirådet. Teknologinævnet was founded by the Danish parliament, as an independent institution to perform TA and promote a national debate on TA- related matters. Since the name-shift it is no longer attached to the Ministry of education, and has as an additional task to function as advisory body to both the government and parliament. In English the name has changed very little, from **The** Danish Board of Technology to Danish Board of Technology.

While it in the indicative approach is typical to (mathematically) extrapolate present experiences into the future, the exploratory approach also incorporates more qualitative aspects and typically is based on the development of scenarios.
Finally, in the normative approach the essential factor is the bringing together of the different parties and catalyzing of interaction between them, only to a lesser extent emphasizing historical developments[151].
In the DHI analysis of biosensors' potential in the health care sector, an exploratory approach was adopted, while it was hoped that the exercise also would be catalyzing new ideas by in the later phases inviting the interested parties to comment upon the report[152]. The main argument put forward by the DHI to have done the analysis in this way was cost considerations.
Now, it may be true that their resources were not sufficient to perform a similar exercise with involvement of all parties, justifying this decision. However, from a societal point of view it may well pay off to increase the budgets of institutes like the DHI if this, through the adoption of a normative approach, would lead to more and better innovations in industry. Innovation in industry namely, ultimately provides employment and generates taxable profits[153]. In my view, the normative CMTA approach, may by simultaneously controlling and stimulating technological developments, and creating desirable futures (see below) stimulate innovations that may ultimately improve quality of care and help contain costs[154].

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[151]See (Jørgensen, 1990, pp.123-124). Different taxonomies exist but the one pictured here seems to fit best with our framework, while one of course should realize that in practice there is overlap between the approaches. One other way of categorizing futures studies which is close the one adopted here is the one which divides futures studies into *Descriptive, Exploratory and Prescriptive* approaches, see (McHale, 1978,p.9).

[152]See (Jørgensen, 1990,p.124).

[153]However, I am not suggesting that only expensive Hi-technologies should/could provide continuous improvements in quality of care and may reduce costs. In Denmark for instance a debate is emerging as to the value of good nutrition in hospitals, which at present according to some is overlooked, and which may improve the quality of life of patients as well as obviously represent a very cheap "treatment". See Berlingske Tidende, 1995.

[154] Or as Jan Leschly, Chief Executive of SmithKline Beecham, has suggested "innovation should not only be encouraged - but strongly supported by all governments and responsible administrators of healthcare systems in Europe as a cost saving measure (emphasis in original) rather than an expenditure (Leschly, 1995, p.6)". I do not claim that the ultimate aim of administrators should be to contain costs, rather that this goal may be achievable in part by the same means that may provide improvements in quality of care; innovation. The ultimate aim of health care providers should be to save lives, not money. That this demands a fine balance in the political arena is another matter.

Analyzing an uncertain future, or creating it ??

Now it is well-known that "we cannot expect to know everything about a medical technology at the time of its introduction, and.. should not underestimate the cumulative significance of numerous incremental improvements"(Gelijns and Laubach, p.37).
What a proactive, CMTA approach suggests is that this is a positive feature for technology assessments, since we can still steer the developments in desirable directions, if and when entering the analysis at an early enough stage. It becomes crucial to realize that:

> *When practising futures research, the researcher is an active anticipator in the development process, no matter he or she wants to be or not, whether he or she is aware of it or not. But what is even more important to notice, this 'anticipatory possibility' belongs to everyone in society. (Mannermaa, 1991, p.364)*

Consequently, futures research:

> *should have a clearly emancipatory interest of knowledge, i.e. it should help people to free themselves from old lines of thought and to create new ideas (and in this way make to make the 'impossible' into the possible) (Mannermaa, 1991,p.364).*

Thus futures studies, and amongst these CMTA exercises, can endorse a view in which individuals, groups, firms, movements, nations etc. are creating/constructing their own future.
Keeping in mind the Pharmaceuticals/Health RA, one could imagine that it may have been very useful to expand the ITP analysis with incorporation of a CMTA exercise. This would indicate a kind of merger between MTA and ITP analysis, which in my view is essential. It perhaps makes sense to coin a new concept which will allow both ITP analysts as well as the traditional MTA agents to see the merits in each other's approaches.
Thus, one can imagine this new form of performing bottom-up CMTA/ITP-analysis simultaneously as a linking of the two previously separated fields; ITP-analysis, with its focus on the stimulation of medical innovations, and MTA focusing on the control of medical technologies. Graphically one may depict this linking of RAA-type ITP and more traditional MTA as shown in Figure2.

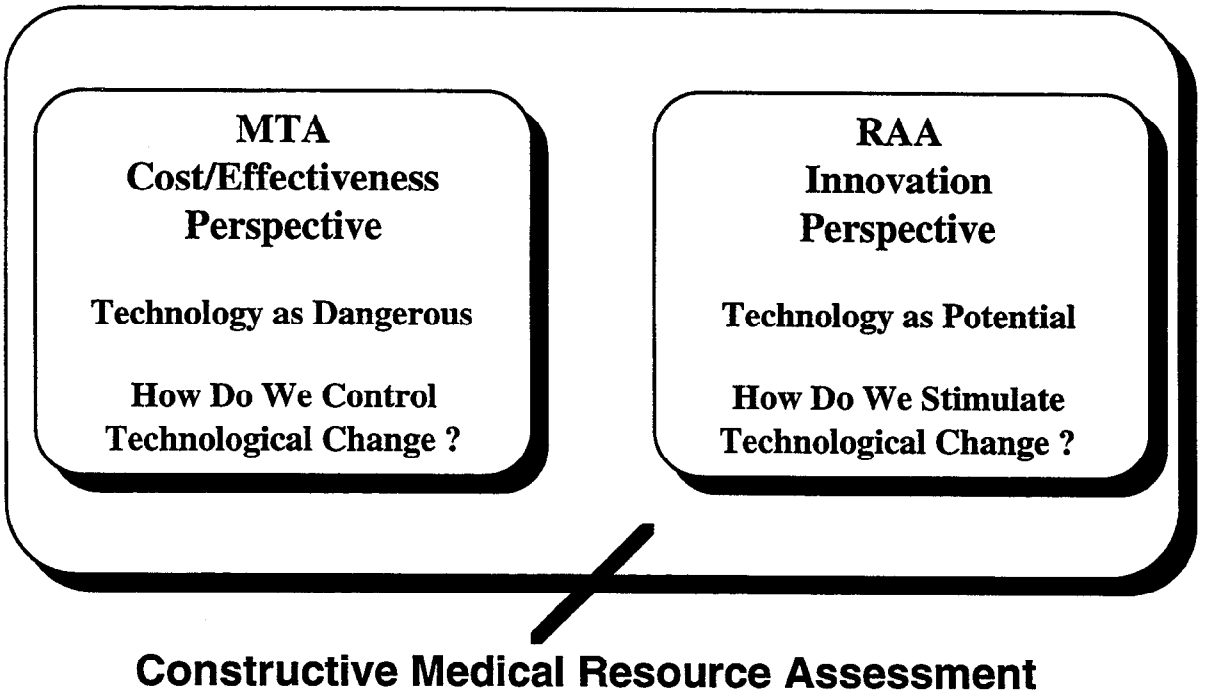

Figure 2. Stimulating and Controlling Medical Technological Innovation Simultaneously: Towards Constructive Medical Resource Assessment ?

In order to stress that what is important is a broad conceptualization of technology, including hardware, as well as more soft aspects, I would like to call this approach Constructive Medical Resource Assessment (CMRA). The term resource should signal the broadening of perspectives associated with the approach.

By way of conclusion

I am well aware that the health sector is known for its cooperation between the various parties, amongst these the role of users in the innovation process. Thus in particular in the area of medical devices/equipment, the importance of incorporating users in the innovation process is well established (Biemans, 1989,1991;Lotz,1991,1993). The CMRA approach neither denies nor discourages this, on the contrary. What it does is argue that the way of thinking in MTA may have to change in order to take serious the stimulation of socially desirable innovations.
Thus, the World Health Organization (WHO) is only partly right when stating that "the roles played in **diffusion** (my emphasis) by health insurance systems, remuneration schemes, medical technical industry, medical leaders, the mass media and consumer expectations should be analysed. (WHO, 1988, p.52)"

Looking through innovation-eyeglasses may teach us, that not only the diffusion of existing technologies should be addressed by such a forum, but the stimulation of potential new developments as well.
Supply does not completely create its own demand, nor does demand entirely determines supply, but the two co-determine each other. This recognition is crucial when realizing that, although not exclusively, health care technology also is an innovation and technology policy issue[155].

[155]Paraphrasing H. D. Banta (1994).

7

Comments on article

7.1 Background of the article

After reading the third article, the reader may want to know why the medical technology area was chosen as the topic of analysis.
After having written about the RAA at large, it was in my view crucial to show the usefulness of the approach in a practical real-life setting, and bring down the theoretical level to a more 'meso-level'[156].
Let me explain why the medical area, which was one of the eight areas covered in the RAA, was chosen for this endeavour.
The first reason, which was rather accidental, was that the pharmaceuticals/health report of the RAA, was the first to come out in June 1993. Before reading this report, which as such can be said to have started a path-dependent process, I had never looked at the medical industry per se.
As I have argued in the introduction to this dissertation, the empirical material plays an illustrative role rather than being applied in the form of a test. When reading about the medical technology area, I became convinced that this was an area which was well-suited to show the relevance of bottom-up ITP in a real-life setting. Furthermore, as my interest in and knowledge of the industry grew[157], it became clear to me that not only could my ITP framework benefit from attending to the medical RAA, but that the opposite was also true. Thus, after completing the first two articles, the new approach called Constructive Technology Assessment (CTA) came to my attention.
The approach lent itself in my view extremely well to complement the RBA to ITP, and this I chose to be the main topic of my third and final article.

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[156] I believe that this endeavour was successful, and that being able to tackle various settings with the theoretical apparatus one builds up during the PhD-project is the main scientific value of the PhD process (see Introduction).

[157] I have mainly focused on the medical device industry, where medical devices "are all types of products used specifically for medical purposes, with the important exclusion of pharmaceutical products." Lotz (1991, p.17).

And here I became aware of the fact that by combining the RBA to ITP and CTA in the medical area, I could hope to achieve two goals at the same time; convince the ITP-community of the relevance of CTA, and convince the (M)TA-community of the relevance of CTA. This since it appears as if the medical TA-community is the most traditional, and probably furthest away from such a broad, dynamic and qualitative approach.
As we saw in Chapter 2.1, the evolutionary/neo-Schumpeterian theories, are sometimes accused of being engaged in technological determinism. While I have argued that this in my view goes too far, Schot (1992) is right in asserting that these type of theories have mainly been concerned with *ex post* market selection mechanisms acting on the variety generated in the variation process. In doing so, Schot argues, the neo-Schumpeterian approach disregards the possible influence of the variation process on the selection process, i.e. does injustice to the co-evolution of technology and its selection environment. In particular it disregards *ex ante* selection, where

> *..influence is exerted on the generation of variations, and thus on the shaping and the choice of heuristics. This form of selection takes place when firms anticipate possible selection by the market (Schot, 1992, p.187).*

Now, the RBA to ITP does by arguing in favour of a bottom-up approach include some mechanism of linking the innovators with their selection environment; it includes some form of *ex ante* selection mechanism. However, by combining the approach with CTA a reunion of the social and technological aspects of the innovation process is created, which makes this co-evolution aspect more explicit. This is the main message that I'll try to convey in this chapter, and in order to do so we'll start by briefly discussing the powerful notions of technological paradigms/trajectories as developed by Dosi (1982).

7.2 Technological paradigms and trajectories

The article by Giovanni Dosi on technological paradigms and trajectories (1982) are matched in terms of influence on neo-Schumpeterian theory only by the work of Nelson and Winter (1982). In the article, Dosi draws a parallel between science and technology, and introduces a terminology based on Thomas Kuhn's (1962) description of the structure of scientific revolutions.
Thus, a *technological paradigm* (the parallel of Kuhn's *scientific paradigm*), is defined (Dosi, 1982, p.152) as a "model" and a "pattern" of solution of *selected* technological problems, based on *selected* principles derived from natural sciences, and based on *selected* material technologies. Such a paradigm, analogue to its counterpart in the scientific world, determines the field of inquiry. A *technological trajectory* (Dosi, 1982, p.152) is then the pattern of "normal" problem solving activity (technological progress) on the ground of a technological paradigm[158].
Technological paradigms, thus Dosi, have a powerful *exclusion effect* ((Dosi, 1982, p.153); the efforts and the technological imagination are focused in rather precise directions, while at the same time the paradigm defines some idea of progress. Furthermore, once *within* a technological paradigm, the economic forces will, together with institutional and social factors, operate as a selective device. Slowly they will exclude more and more trajectories, and increase the *determinateness* of selection.
This process is consistent with Sahal's (1985) interpretation of technological evolution. He showed the process of technological evolution is determined by the *interplay of chance and necessity*, rather than one at the exclusion of the other. This is consistent with Dosi's point of view, since initially when the paradigm is relatively ill-defined chance determines the selection of trajectories, but as the determinateness of selection increases necessity takes over chance's role more and more[159]. Now, Dosi provides a list of features that may clarify the notion of technological trajectories (Dosi, 1982, p.154):

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158 Again this is parallel to Kuhn's conceptual framework, which defines "normal science" as the actualisation of a promise contained in a scientific paradigm

159 Sahal's main thesis in this article is that the process of innovation can for a great deal be explained by the *web of links* between the functional performance of a technology, and it's size and structure . He thus describes technological evolution as a process of *learning by scaling* .These considerations in turn point to a trilogy of innovations, corresponding to three main types of innovation. These are (1985,p64) **structural innovations** - those innovations that arise out of the process of differential growth, whereby the parts and the whole do not grow at the same rate. **material innovations-** those innovations that are necessitated in an attempt to meet the requisite changes in the criteria of technological construction, as a consequence of changes in the scale of the object (product). **systems innovations-** those innovations that arise from integration of two or more symbiotic technologies, in an attempt to simplify the outline of the overall structure.
Also Abernathy & Utterback's (1978) concept of *dominant design* fits well with the process described by Dosi. They claimed that the occurrence of such a dominant design will lead to a shift

1. There might be more general or more circumscribed, as well as more powerful or less powerful trajectories[160].

2. There generally are *complementarities* among trajectories[161].

3. In terms of the model the technological frontier can be defined as the highest level reached upon a technological path, with respect to the relevant technological and economical dimensions.

4. Progress upon a technological trajectory is likely to retain some cumulative features: the probability of future advances is in this case related also to the position that one (firm or country) already occupies vis-a-vis the existing technological frontier.

5. Especially when a trajectory is very powerful, it might be difficult to switch from one trajectory to an alternative one.

Finally, Dosi writes,

6. It is doubtful whether it is possible *a priori* to compare and asses the superiority of one technological path over another. There might indeed be some objective criteria, once chosen some indicators, but only *ex post*.

Now it is particularly this claim that CTA contests. CTA does accept Dosi's point that market-mechanisms are generally weak in the *ex ante* selection of technical directions, especially at the initial stage of the history of an industry ([Dosi, 1982, 155).
However, as the title of the introduction to the main work on CTA to date (Rip, Misa & Schot, 1995) reads **Steering Technology is Difficult but Possible**.

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from radical to incremental innovations. In the conceptual framework of Dosi, a dominant design may be defined as an extremely well defined best practice design in a highly determined trajectory.

[160]This may be connected to the concept of *generic* technologies. These technologies, may have such extremely wide ranges of application that their trajectories exhibit a "fixed" mode of thinking that is so widely applicable that it's exclusion effect might be limited.

[161]This may be linked to Rosenberg's concept of the *key sector*. In his well-known case study on the American machine tool industry (Rosenberg, 1976), it is argued that certain occupations (industries) - in *key sectors* - may have substantial spin offs and can be a crucial factor in enhancing economic growth. The importance of such a *key sector* lies in the fact that the new skills and techniques that are developed in it, are transmitted to other trajectories and avenues rapidly. While Rosenberg states, that this is possible due to *technological convergence* and specialisation, alternatively we may say that the existence of complementarities among trajectories is what (at least partly) facilitates this.

7.3 Technology Assessment: From *watch dog* to *tracker dog* ?

> Technology is never purely technological: it is also social. The social is never purely social: it is also technological. This is something easy to say but difficult to work with. So much of our language and so many of our practices reflect a determined, culturally ingrained propensity to treat the two as if they were separate from each other.
>
> J. Law and W. Bijker (1992, pp305-306)

As I have argued in the article, the recognition that technological change is a social process and that its diffusion depends on social acceptance implies that ITP has to shift from its traditional supply-side focus to a more demand-side oriented approach, due to .
Also explained in the article is the fact that the new - constructive - approach to TA, may lend itself particularly well to be an input to such a demand-side oriented ITP.
Smits, Leyten and den Hertog (1995)[162], in line with my article argue that TA should play an increasingly important role in ITP analysis/formulation, since the two-tracked approach of separating the control and stimulation of technological change is outdated. In order to clarify the differences between the old TA-approaches and the new type of TA, they present the following table.

Table 7.1

Conventional TA-concept	*New TA-concept*
Dominant role of science	Equal role for researchers and users
High expectations of the potential of research	Modest expectations of TA-research
TA-output: study report	TA-output: study and discussions
Little attention for problem of definition	Much attention for problem of definition
One TA-research organization	Multiform TA-research community
Instrumental use of TA-information	Conceptual use of TA-information
TA results incorporated in decision-making	"Tuning" of TA and decision-making
Autonomous technology	Technology as human creation

Source: Smits, Leyten & den Hertog, 1995, p.280

What this table above all illustrates is the broadening of TA, and the recognition of its role as part of a process.

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[162]It is possibly an indication of academic rivalry that these authors were not included in the book by Misa et al 1995, since the views are so identical (with both groups firmly established in the Netherlands) that it almost hard to believe they did not cooperate extensively.

In the early days of TA, which started in the USA in the end of the 1960s, TA focused on providing 'early warnings' as to the side-effects of different technological developments.
In doing so, TA was supposed to act as a neutral observer that provided objective information to which policymakers could react. As van Eijndhoven has argued however (1995), TA proved far from neutral and the tendency towards very (overly?) critical assessments led to its nicknames: Technology Arrestment/Technology Harassment.
In the mean time however, as van Eijndhoven (1995) argues, the focus of TA has shifted from supplying criticism to trying to identify opportunities, "from adjusting to steering". In my view this is well illustrated in table 7.1, in particular in that now the focus is on the conceptual use rather than the instrumental use of TA. As I write in the article

> *The National Board of Health in Denmark, has for several years argued, that MTA should become a* way *of thinking (29;30)*

and,

> *Incorporating the innovation objective, will be shown to necessitate a conceptual shift in this way of thinking, towards a more qualitative, broader and normative approach.*

This is precisely what is implied by this conceptual rather than instrumental use of TA, as I understand it.
Besides providing this interesting tablet Smits, Leyten and den Hertog (1995) make a very useful discussion of TA operating at three different levels. These three levels are: awareness, strategy[163] and implementation.
Especially the latter one is important here, since it focuses on the stimulation of interactive learning processes and experimental modes of operation is crucial.
The authors then reserve the term Constructive TA (CTA) for this implementation level activity, more precisely meaning the neutral process of exchange of information, that should replace the market mechanism by linking the supply and demand-sides of technological change.

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[163]**Raising awareness.** Awareness TA (ATA), has according to the authors two equally important functions: 1)To analyse the potentials of new technological developments, and provide clarify the social choices that exist/can be created relating to these developments. 2)The converse function of analysing potential social developments and increased awareness of potential demands and expectations, which may be translated into technological developments.
Formulating strategy. This form, Strategic TA (STA), is mainly oriented towards the development of strategies within sectors of society, and involves the institutional mapping, creation of reference points for discussion (within the sector) and networks, and identifies needs for collective action.

The title of this section TA from watch dog to tracker dog is also borrowed from Smits, Leyten and den Hertog (1995), and in my view captures very well the shift in focus represented in TA activities.
Some however may claim that TA has moved from technology harassment towards an overly optimistic account of its constructive role. Especially, the question is sometimes raised if path-dependency (which is accepted within CTA) doesn't prevent/exclude the possibility of steering technological development ? The answer is no!
Firstly as it reads in table 7.1 the expectations in the new type of TA are 'modest', and claiming it is possible to steer is not the same as claiming we can steer it in the 'right' or optimal direction. Secondly, and related to this, the existence of technological paradigms/trajectories does not mean that CTA is futile. As Misa, Schot and Rip argue such a conclusion is based on a misinterpretation of the notion of trajectories/paradigms.

> *Indeed, if technical trajectories are conceived as akin to the path of projectiles moving through empty space, impelled by some prime mover, all efforts at shaping technical developments - including CTA - would be futile. Such a mistaken conception of Dosi's and our notion of trajectories is a prominent feature of recent social constructivist analyses of technical change. Three essays in Bijker and Law (1992) reject the concept of trajectories, which is apparently misunderstood as being restricted to the patently false notions of unilinear development, the simplistic unpacking of assumptions built into previous technologies, and even inexorability.*
> *Given the insight that trajectories are active constructions, it is possible in principle to alter them and thereby effect change in even well-entrenched and high-momentum technologies(Rip, Misa & Schot, 1995, p.54)*

Thus, eventhough path-dependencies will result and the possibilities for change will be context-dependent, we can change them although we naturally cannot predict precisely how are actions will affect the eventual outcome.

7.4 Towards the conclusion

After having discussed briefly here the third article, it is time to conclude the thesis with a short discussion and overview of arguments developed. It is to this we now turn.

8

By way of conclusion

The structure of this thesis, and its aim at generating descriptive theory, in my view can lead only to one type of conclusion of this dissertation; items for future research. Especially in light of my arguing in favour of a dialogue-based, bottom-up approach to ITP, it can hardly be surprising that I alone cannot provide a definite answer to the question how ITP should look in contemporary society. Or, as I already wrote in Chapter 1.3

> **Innovation is a complex/systemic process, and in order to address it and the policies aimed at promoting/steering it, we need an equally broad, multi-disciplinary framework which ranges from micro- to macro-levels of analysis.**

While I hope to have raised most of the relevant issues pertaining to real-life ITP, and in doing so have intrinsically linked it to firm strategy, the relevant topics to be dealt with are far from exhausted.
The first critical issue that still needs to be explored is the link between 'economics-based' ITP theories in general, and the RBA to ITP in particular, and political science. Thus, while my Science and Public Policy article deals with some of the implementation issues involved in ITP, I believe that a closer link between my kind of approach and political science is necessary to operationalise ITP theory.
Related to this, there is the need to link 'economics-based' ITP theories in general, and the RBA to ITP in particular, to macro-economic theories. Over the last few years, with the economics of innovation/technological change gaining in status, the field has tended to isolate itself from recent developments in macroeconomics. Thus, while nearly all innovation economists agree that sound ITP should be integrated and coordinated with more general macro-economic policy, there is not much effort to specify precisely how.

In my view there is great potential in exploring this issue, in particular since through the appeal macro-economics has to a large (and different) group of researchers, these may be drawn into the economics of innovation and become a source of renewed inspiration.
Cultural factors that promote/retard innovation are another crucial topic deserving future research efforts. In this light it may be interesting to compare the Danish RAA with exercises in other countries, and to what extent the RAA can/cannot be generalised/'exported'. Related to this is the issue of differences between large and small countries in terms of their needs for ITP. One may for instance expect that larger countries with a greater degree of 'autarky' have different needs in terms of upholding absorptive capacity. Also larger countries may to some degree be able to pick winners due to the critical mass of resources they may be able to foster to create a self-reinforcing process.
Finally, the issue of the relationship between routines and innovation is an important research topic. Thus as I argued in Chapter 4.4 the resource-based view treats routines in a positive sense as a source of inimitability, while evolutionary theory views them as a proxy for inertia. Clarifying this dichotomy is crucial, since an important part of ITP must relate to the existing/required routines at the firm-level. Realising when these are beneficial, and when they would retard innovation and growth thus is of the utmost importance in designing sound policies.
As the reader will notice, the endeavour to create a synthesis between micro- and macro- theories to explain/guide ITP should in my view not stop here and now.
Many important issues, also beyond those mentioned in the above list, still remain. This dissertation may be seen as a first building block of a resource-based theory of innovation and technology policy. I believe that if strategists, policymakers and theoreticians from different disciplines will put their heads together and develop this framework further, it may be the beginning of a beautiful friendship.

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