Scenarios and Structural Uncertainty
Explorations in the Field of Sustainable Transport

Karl Henrik Dreborg

Department of Infrastructure, KTH
Department of Environmental Strategies Research, fms, FOI
TRITA-INFRA 04-001
ISSN 1651-0216
ISRN KTH/INFRA/R-04/001—SE

Author/Författare
Karl Henrik Dreborg

Publisher/Utgivare
Department of Infrastructure
Royal Institute of Technology, Stockholm, 2004
Doctoral Dissertation

Title/Titel
Scenarios and Structural Uncertainty:
Explorations in the Field of Sustainable Transport

Abstract
The aim of this study was to develop and use scenario approaches and gaming as planning tools, and thereby make a contribution to both planning and research, especially in the areas of application of 1) crisis management and emergency planning and 2) sustainable transport. The analysis of uncertainty and the design of tools to cope with it are core contributions. The Thesis consists of four Papers.

In Paper 1 the connection between gaming and tacit knowledge is examined. Based on cases and literature, concepts and typologies that would permit a more accurate analysis of the relationship between purpose, design and validity of games are suggested. In Paper 2 the niche for backcasting is identified. Basic assumptions behind it are compared to those behind traditional forecasting. Papers 3 and 4 describe the development and use of mixed futures study methodologies. In Paper 3 scenarios for a decision support tool for transport policy analysts at the European and national levels are developed. In addition a methodology for the linking of scenarios to a modelling system in such a way that relevant uncertainties could be high-lighted is suggested. In Paper 4 the main task was to construct scenarios for achieving sustainable mobility and thereby give an input to policy development at the European Commission and at the national level. A combination of external scenarios and backcasting is developed that allows an analysis of how strategies for achieving visionary goals can be adapted to various external developments.

In the introductory part of the Thesis, a conceptual framework and a perspective on planning, futures studies and uncertainty is presented. Structural uncertainty is a key concept. It prevails when there is no reliable model of the systems dynamics that permits predictions over the time frame of interest. In contrast, quantitative uncertainty refers to the development of external variables, while a reliable predictive model of the systems dynamics is assumed to exist. Whereas predictive modelling, probabilistic approaches and sensitivity testing are suitable in the case of quantitative uncertainty, scenario approaches and sometimes gaming are the better choice in the face of structural uncertainty.

Key words
Scenarios, backcasting, structural uncertainty, gaming, tacit knowledge, sustainable transport
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>PREFACE</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF PAPERS</td>
<td>xl</td>
</tr>
<tr>
<td>I. AIM AND SCOPE OF THE STUDY</td>
<td>1</td>
</tr>
<tr>
<td>II. A PERSPECTIVE ON PLANNING, UNCERTAINTY AND FUTURES THINKING</td>
<td>4</td>
</tr>
<tr>
<td>1. Uncertainty and planning</td>
<td>4</td>
</tr>
<tr>
<td>1.1 Models in planning</td>
<td>5</td>
</tr>
<tr>
<td>1.2 Structural uncertainty</td>
<td>6</td>
</tr>
<tr>
<td>1.3 Uncertainty and strategy: Static vs. dynamic uncertainty</td>
<td>9</td>
</tr>
<tr>
<td>1.4 Structural uncertainty and the time-frame of planning</td>
<td>10</td>
</tr>
<tr>
<td>1.5 The case for gaming</td>
<td>13</td>
</tr>
<tr>
<td>1.7 Summary</td>
<td>14</td>
</tr>
<tr>
<td>2. Exploring the future</td>
<td>16</td>
</tr>
<tr>
<td>2.1 Brief history of futures studies</td>
<td>16</td>
</tr>
<tr>
<td>2.2 Three modes of thinking about the future</td>
<td>18</td>
</tr>
<tr>
<td>2.3 Combined methodologies</td>
<td>20</td>
</tr>
<tr>
<td>2.4 Predictive modelling</td>
<td>21</td>
</tr>
<tr>
<td>2.4 The case for scenario approaches</td>
<td>23</td>
</tr>
<tr>
<td>3. Two scenario approaches</td>
<td>24</td>
</tr>
<tr>
<td>3.1 External scenarios for strategic planning</td>
<td>27</td>
</tr>
<tr>
<td>3.2 Backcasting</td>
<td>30</td>
</tr>
<tr>
<td>3.3 Comparative discussion of the scenario approaches</td>
<td>31</td>
</tr>
<tr>
<td>3.4 Summary</td>
<td>36</td>
</tr>
<tr>
<td>III. REFLECTIONS ON PAPERS 1-4</td>
<td>37</td>
</tr>
<tr>
<td>4. Paper 1: Learning by Gaming</td>
<td>37</td>
</tr>
<tr>
<td>5. Paper 2: Essence of Backcasting</td>
<td>40</td>
</tr>
<tr>
<td>6. Paper 3: The STEEDS decision tool</td>
<td>43</td>
</tr>
<tr>
<td>7. Paper 4: The POSSUM study - Policy scenarios for sustainable mobility</td>
<td>46</td>
</tr>
<tr>
<td>IV. CONCLUDING REMARKS</td>
<td>50</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>55</td>
</tr>
<tr>
<td>APPENDICES WITH PAPERS 1-IV</td>
<td></td>
</tr>
</tbody>
</table>
Preface

This thesis is based on my long professional experience at the Swedish Defence Research Institute (FOI, before 2001 called FOA) of two fields of application: strategic planning and systems analysis for the defence sector and systems studies of sustainable transport. In both cases the planning horizon is long and the uncertainties involved are considerable and can often only be partly resolved. Hence, there is a need for analytical tools to structure the remaining uncertainty in order to support decision making with a long-term view, but also for methods for the training of personnel in charge of crisis management in the event of war or civil emergency situations. Here scenarios and gaming proved to be useful methodologies, especially in the face of structural uncertainty, a concept that is analysed in the introductory part of the thesis.

Around 1990 I led a project aimed at developing methodologies for gaming, especially for crisis management on the civil side of defence. It was intended to improve FOA’s expertise on gaming and its ability to guide customers, mainly some Government boards, county administrative boards and municipalities. The main report (in Swedish) formed a major part of my licentiate thesis. Here, an English summary of results based on the Swedish report appears as Paper 1.

In 1993 I joined a group that was being built up by the late Peter Steen. It was called the Environmental Strategies Research Group (fms) and was a joint undertaking by FOA and the Department of Natural Resources Management at Stockholm University, where Peter held a position as part-time professor. fms developed into a truly interdisciplinary group, a think-tank that carried out systems studies of sustainable development in the fields of transport, urban development and resource use and re-cycling. During recent years a fruitful cooperation with the Royal Institute of Technology, KTH, has been developed. This has led to the establishment of a Centre for Environmental Strategies Research at KTH in December 2003.

At fms we applied the scenario methodology called backcasting to the study of sustainable transport and this led me to write the article Essence of Backcasting, which is Paper 2 of this thesis. It is an investigation into the rationale of backcasting and the basic assumptions behind it. This article is the second part of my Licentiate thesis, defended in 1997.

From 1995 on, fms became involved in several projects within the EU framework programme for research, and Papers 3 and 4 are based on my contributions to the transport and environment orientated projects STEEDS and POSSUM respectively. In these papers, methodologies were developed for coping with structural uncertainty and structural change, the main themes of this thesis. The methodological approach was broadened to incorporate external scenario methodologies similar to that of Shell. In both projects, combined methodologies were developed. In STEEDS, external scenarios were combined with a mathematical modelling system that
allowed sensitivity testing as well as an exploration of structurally different futures. In POSSUM the backcasting approach was combined with external scenarios in order to allow an analysis of how strategies for achieving visionary goals can be adapted to various external developments.

By putting the four papers together and adding a conceptual framework and a perspective on the use of scenario methodologies in the face of structural uncertainty, I hope to make a contribution to expertise building in this field at fms, FOI and KTH.

Many people have helped me by providing criticism, support and inspiration that made me go on and improve my work. First of all I would like to thank Peter Steen, who built fms and made it such an inspiring environment for creative work. As a leader but also a friend, he always supported me and showed confidence in my work. He had a talent for asking intriguing questions and challenging conventional truths that I found so reviving.

My supervisors Folke Snickars at the Royal Institute of Technology and Anders Karlqvist, Swedish Polar Research Secretariat, have guided me carefully past many pitfalls. I am grateful for the interest and faith in my work that they always showed, as well as for their constructive criticism. I always enjoyed our discussions and the friendly atmosphere at our meetings.

I am also grateful to my superior at FOI, Jan Foghelin, Head of the Division of Defence Analysis, for his sympathetic attitude and encouragement to finalise my thesis and for funding part of the work.

The research environment at fms has meant much to me. I am grateful to all my colleagues at the group for their curiosity, broad interests and willingness to take part in discussions. In particular I want to thank Jonas Åkerman, Anders Gullberg, Mattias Höjer, Sven Hunhammar and Jessica Johansson for valuable comments on drafts of the thesis. Jonas is also co-author of Paper 4. I am thankful for his willingness (and great ability) to penetrate in depth any question raised in our discussions. Mattias and I have discussed various scenario methodologies at length and I have greatly appreciated our discussions and his inventiveness. The recurring discussions have given me several new insights and led me to a broader view. Leif Hedberg was also a most constructive member of the POSSUM project team, in the wake of which Paper 4 was produced. Göran Finnvelden and I have discussed the relative merits of different scenario approaches for the application to Strategic Environmental Assessments and Life Cycle Assessments. In this context Göran has contributed ideas to the perspective on scenario methodologies put forward in the thesis. For that I am grateful.

Anders Eriksson at the Division of Defence Analysis at FOI and I have worked together in several projects during the last 15 years. Anders is also co-writer of Paper 3. We have had numerous stimulating discussions on planning under uncertainty and scenario approaches, especially the scenario planning variety of Shell and Global
Business Network. Anders' broad view and sharp analyses of issues discussed have influenced my thinking. I am also grateful for useful comments on a draft of the thesis.

I want to thank Lars Ingelstam, discussant at the final seminar, for constructive critique and valuable suggestions for improvement.

I am also grateful to David Moon, excellent coordinator of the EU-project STEEDS of which Paper 1 is part, and to all the partners of the consortium for the great collaboration. I would particularly like to thank Alain Wouters at Whole Systems, co-writer of Paper 3. I learnt a lot about scenario development and workshop methodology from him.

The co-authors of Paper 4, partners of the consortium of the POSSUM project, were so stimulating to work with. I am grateful to David Banister for his effective, yet graceful way of leading the project work. All authors made contributions to all parts of the book, but with different emphasis. Besides my own contributions as regards scenario methodology and design, in Part two (Paper 4) Jonas Åkerman, Peter Steen and Ruggero Schleicher-Tappeser made contributions to the design of policy packages and paths, while Dominic Stead gave input on indicators of sustainability. Jonas elaborated on the scenarios and calculated transport volumes and their impact on CO2 emissions. I am grateful to them and to Peter Nijkamp for the collaboration and for useful comments on the scenario design.

This work would not have been possible without my family. My wife Gunnel and my daughters Susanne and Maria have constantly been encouraging and I have felt their unwavering faith in me. This has been of invaluable importance to me and kept me going. Throughout the entire work Gunnel and I have had inspiring discussions, which have influenced the forming of the perspective put forward in the thesis.

Paper 1 was funded by FOI. Paper 2 was funded as part of a Swedish transport futures study by the Programme for general energy systems studies (AES) at the Swedish National Board for Industrial and Technical Development (NUTEK), now merged into the Swedish Energy Agency, and the Swedish Board for Transport and Communications Research (KFB), now part of the Swedish Agency for Innovation Systems (VINNOVA), and The Swedish Council for Building Research (BFR), now merged into the Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas).

Papers 3 and 4 were partly funded by the European Commission within the EU framework programme for research. Both were co-funded by KFB. The final work on the introductory and synthesis part of the thesis was funded by Formas and FOI.

Stockholm January 2004

Karl Henrik Dreborg
List of Papers


I. Aim and scope of the study

This study is about gaming and scenario methodologies as planning instruments. It comprises four research papers, where the first is a mainly methodological and theoretical contribution to the field of gaming with applications in civil emergency planning and crisis management, especially at a local and regional level. The other three papers are contributions as regards scenario methodologies, with applications in transport planning and sustainable development. A common denominator of the different parts of the study is a focus on planning tools that make sense in the face of uncertainty. On the following pages, this and other key concepts are discussed and combined into a conceptual framework and a perspective on uncertainty, planning and futures studies, used for the analysis and comparison of Papers 1 – 4.

The four papers on which this thesis is based are:


The overriding aim of the study was to develop and use scenario approaches and gaming as planning tools, and thereby make a contribution to both planning and research, especially in the areas of application of 1) crisis management and

emergency planning and 2) sustainable transport. The analysis of uncertainty and the design of tools to cope with it were core contributions.

The aims of papers 1 – 4 were respectively:

Paper 1: The project aimed at increasing the ability of the Swedish National Defence Research Establishment (FOA) to assist and provide advice to clients in their use of gaming, especially in planning for civil emergency preparedness. Instrumental to this was the development of concepts and typologies that would permit a more accurate analysis of the relationship between purpose, design and validity of games in this field.

Paper 2: The aim was to identify the niche for backcasting by describing conditions that speak for this approach. A further aim was to identify basic assumptions behind backcasting and to compare them with those behind traditional forecasting.

Paper 3: The aim of the project was to develop a decision support tool for transport policy analysts at the European and national levels, the main purposes of the tool being:

- to project the market uptake of different transport technologies under various scenarios and policy options;
- to assess the energy, environmental and other impacts of these different technology mixes.

My specific contribution to this EU-project was to coordinate a work package on external scenarios and to design the linking of scenarios to the modelling system in such a way that relevant uncertainties could be high-lighted.

Paper 4: The main task was “…to construct scenarios for achieving the objectives of sustainable mobility and to assist in future decision-making about the Common Transport Policy and the development of the Trans-European Networks.” (Banister et al. 2000)

My specific contribution to this EU-project was the architecture of the scenario set and the methodology of combining an external scenario approach and backcasting.

A conceptual framework and a perspective on planning, futures studies and uncertainty is presented in Part II of this thesis. The aim of this framework is to put the methodologies of Papers 1 – 4 into a context and to facilitate an analysis and comparison of these studies.

Different kinds of uncertainty are discussed in Chapter 1. Of special interest are the concepts of structural uncertainty, quantitative uncertainty, uncertainty of intentions and unspecified uncertainty. Structural uncertainty prevails when there is no reliable model of the systems dynamics that permits predictions over the time frame of interest. The development may go in quite different directions and there is no solid ground to be found for dismissing all but one track as impossible. In contrast, quantitative uncer-
tainty refers to the development of external variables, while a reliable predictive model of the systems dynamics is assumed to exist. In such cases sensitivity testing of external variables is an example of a useful method to analyse uncertainty. A special variety of structural uncertainty is *uncertainty related to intentions*, which appears in systems of relatively few interacting agents (individuals or institutions) with more or less conflicting interests.

Unspecified uncertainty prevails when we cannot specify what *variables* (factors, drivers etc) are salient to the development of the system of interest. In the case of structural uncertainty one could say that we cannot specify the *equations* governing the system.

Quantitative uncertainty and structural uncertainty call for different analytical tools for the exploration of the future. Whereas predictive modelling, probabilistic approaches and sensitivity testing are suitable in the case of quantitative uncertainty, scenario approaches and – in the case of intentional uncertainty - gaming are the better choice in the face of structural uncertainty.

In Chapter 2 I suggest that there are three basic modes of thinking about the future, namely the predictive mode, the eventualities mode and the visionary mode. Each is reasonable and helpful under some circumstances as a way of preparing for the future, in everyday life as well as in professional contexts. To each of them, there is one or several systematic methodological approaches that are used in studies, with the aim of informing business and/or public sector planning. Approaches that have one of these modes of thinking as its basic perspective I shall call pure.

In Chapter 3, I discuss the pure methodologies of predictive modelling, scenario planning and backcasting, with an emphasis on the latter two. I also discuss mixed methodologies that utilise at least two of the modes of thinking and related methods.

In Part III, Papers 1 – 4 are discussed and related to the perspective and concepts described in Part II.

In Part IV, I make concluding remarks on the conditions for application of the planning tools studied.
II. A perspective on planning, uncertainty and futures thinking

1. Uncertainty and planning

In most planning, uncertainty poses a problem that has to be dealt with. In the related traditions of Operations Research (OR), Systems Analysis (SA) and Policy Analysis, considerable attention is devoted to various kinds of uncertainty and ways of coping with it (Strangert 1974; Dror 1988; Rosenhead 1989b). The present work mainly belongs to this tradition, but it has also been influenced by the scenario planning developed at Shell and by backcasting in the field of sustainable development.

In its early phases the OR/SA tradition was characterised by a rationalistic approach to planning, sometimes called synoptic planning (Friedmann 1987, p. 129; Sager 1994, p. 8 ff.). The synoptic model uses a sharp distinction between decision-makers who define the goals and the planners or analysts who explore what means there are and assess their relative effectiveness. This view of planning as objective and rational has been criticised by other planning theoreticians (Lindblom 1959; Mintzberg 1994, pp. 13 and 189-193). Influential schools of planning theory maintain that in practice planning is more reactive than goal-orientated in character and that it is often characterised by bounded rationality. Critics of the synoptic planning model usually emphasise the importance of a broad participation and effective communication in the planning process. These views are typical of the planning schools of "muddling-through" (Lindblom 1955), radical planning (Friedmann 1987, pp. 389-412) and communicative planning (Sager 1994).

Starting in the 1970s, more process-orientated and participative variants of SA have been developed, which are less affected by the criticisms mentioned above. British problem-structuring methodologies (Rosenhead 1989a) such as Soft Systems Analysis (Checkland 1981) and SODA (Eden 1989) are prominent examples. Furthermore, the critics of the SA tradition sometimes underestimate the merits of instrumental rationality and goal-orientation. These often have an important role to play in a planning process, and need not preclude a broad participation and effective communication. When the planning body is faced with a problem that involves long lead times and the possible need for long-lasting investments (as e.g. in defence planning and infrastructure planning), then a rational analysis of policy options is of particular importance. The potential benefit is an awareness of a broader scope of options and associated threats and opportunities. Here scenarios and gaming may help considerably. It is worth stressing that these tools are well suited for a participative planning approach and are potentially effective means of reconciling the rational and the participative elements of planning.2

---

2 A similar view is expressed and elaborated on by van der Heijden (1996, p 49).
1.1 Models in planning

In planning practice and the science of planning, models of the system of interest are sometimes used in order to explore likely or possible developments as well as policy options and their consequences. These models may be purely conceptual, describing the relationships between phenomena in a qualitative manner, or quantitative with well-defined functional relationships between a set of variables.

Even though the usefulness of models in planning may be limited in some contexts, a model-orientated approach is used here as a starting point for discussing both the cases where it is applicable and the cases where other approaches are needed.

In planning literature of the rationalistic kind, a formal models approach is often adopted as a theoretical framework (e.g. Strangert 1974; Johansen 1979). In this approach a model of the system that describes functional relationships between variables is assumed, as is a set of external variables and policy variables (see Figure 1). In this case uncertainty is specified and confined to what values the external variables will adopt in the future. As to the impact of a given set of external and policy variables, the planner relies on the model according to this approach. In most of this thesis, I explore cases where these assumptions are not valid and, hence, other planning tools are needed. However, for reasons of comparison I first devote attention to the case where a predictive model of the system of interest is feasible.

![Figure 1: Model-based planning](image)

Transport planning of an urban area can be used as an illustrative example. If a model of the transport system is to be developed, the aspects of reality to be covered must first be decided. This is step 1, which entails the choice of factors that should be included as variables. Every model is, by necessity, a simplification. By focusing on the most salient factors while leaving out phenomena considered to be of minor relevance to the issue at stake, the planning problem becomes tractable. The next step is to decide which factors should be internally determined variables (i.e. in the model) and which should be treated as externally determined variables. Some of the external variables may be levers that policy makers can decide on (within limits) in order to make the transport system attain desirable goals (output) such as good
accessibility, low environmental impact and acceptable levels of equity among user categories.5

When the model is built and validated, it can be used to predict the development conditional on policy choices (policy variables) and the development of external variables. Policy options could be taxes, fees and rebates on various kinds of travel behaviour. The level of household income is an example of an external variable in transport demand models.

A more fundamental kind of uncertainty prevails when the set of variables or the equations of the model cannot be specified with certainty. When the variables cannot be (completely) specified, I use the term **unspecified uncertainty**, following Strangert (1974, pp. 34-36). When the equations cannot be specified, the term **structural uncertainty** is used.4 Clearly, if the variables cannot be specified, no model can be built. In such cases we are faced with both unspecified and structural uncertainty. On the other hand, the possibility to specify variables does not guarantee that a model can be built. The functional relationships between variables may still be difficult to determine with certainty. Hence, we may have structural but not unspecified uncertainty.

In many cases it is possible to identify a number of important variables (drivers) of a system and to outline a model, but there is still the possibility that some factor (variable) of importance has been left out. In such cases the model may give accurate (conditional) predictions for some time, but there is always the possibility of surprise. A completely unexpected event or development turns out to have an impact on the system of interest.

In the next section, I analyse the concept of structural uncertainty, which is key to understanding the role of scenarios in planning. The concept of unspecified uncertainty is used in the context of gaming, in Chapter 4.

### 1.2 Structural uncertainty

The modelling approach described above is feasible when the dynamics of the system of interest are well known and predictable. Then, a model can be made that is reliable for the relevant period of time, and uncertainty is essentially confined to the development of external variables, i.e. input to the model. The corresponding uncertainty of model output can usually be described as an interval of uncertainty for some variable. In the transport system example this could mean that uncertainty as regards household income in the future (the external variable) results in uncertainty of the development of transport demand (output), described by an interval of possible outcomes. The uncertainty is quantifiable, at least on a judgmental basis.

---

3 In Section 3.1 a partly different distinction between external and internal is introduced.
4 It could be argued that the term unspecified uncertainty could be used in both cases, since what I call structural uncertainty means that equations cannot be specified. However, I prefer to make a distinction between the two variants, because the focus in this study is on what I call structural uncertainty.
Some sources call it quantitative uncertainty (Eriksson forthcoming), a term that I also use in this work.

If, on the other hand, no single predictive model of the system’s development can be found that is reliable within the time frame of relevance to the planning issue at stake, then the system can be said to be characterised by structural uncertainty. From the point of view of best available knowledge, structurally different futures are then possible. Thus, structural uncertainty pertains to the system dynamics. Below, I discuss three variants of structural uncertainty.

In the first case (A), it is possible to conceive of more than one model of the system and it is impossible to discriminate between them for the relevant period of time. It is then possible to develop two or more scenarios related to different models of the system’s dynamics. A step in this direction was taken in the STEEDS project, described in Paper 3 (see this and Chapter 6). The models were similar but for some modifications of a few functional relationships. This, however, was enough to map structurally different futures outlined in the scenarios.

In the second case (B), the long-term dynamics of the system are understood (at least hypothetically) and possible to model, but the adequate model is not predictive as to the relevant planning aspects. This is the case of non-linear dynamics that has been extensively explored in many scientific disciplines during recent decades. Both deterministic and stochastic models may be of relevance. In the deterministic case, the system is typically characterised by sensitive dependence on initial conditions. A small change of a variable may lead to a completely different trajectory. The present state of the variables may not be possible to measure with sufficient accuracy to permit predictions of the system’s development. Depending on initial values, the system approaches different attractors. This is the case of path dependence and lock-in. If the attractors are known, these could form the basis for different scenarios.

An interesting variant of stochastic processes is the ergodic dynamic, which is a process that shows a long run pattern in the sense that it tends to approach a limiting distribution for time spent in the different states of the system, regardless of where the process starts (Young 1998, p. 48). This means that the process is not path dependent, neither is there a permanent lock-in to any one state. However, the process may rest for longer or shorter periods in several states (temporary lock-in).

---

1 Eriksson (forthcoming) uses the term qualitative uncertainty.
2 Pioneer contributions were made by Smale (1967), Lorenz (1979), May (1974), Mandelbrot (1983) and Feigenbaum (1978).
3 There are other stochastic models of interest. Arthur (1996) uses a stochastic model to analyse markets for goods and services to be used in networks such as computers or technological standards. Here, positive feedback mechanisms are in operation, reinforcing an early lead for one of the competitors until he or she takes most of the market, as illustrated by the competition between Macintosh and PC. However, in the early stages of the process it is impossible to predict who will come out on top, because of the sensitivity of the process to early chance events that may favour one or the other of the actors on the market. A similar dynamic model is suggested for location of firms in an emerging high-tech industry like ICT, characterised by agglomeration advantages (Arthur 1990).
Again, it is possible to develop scenarios based on these stochastically stable states, where the process tends to rest for non-negligible time periods (Young 1998, p. 54). Social dilemmas (Dawes 1980) such as the tragedy of the commons (Hardin 1968) often entail social norm formation as an important element. This is a process that can be interpreted as ergodic. The system alternately rests in a position with a high degree of cooperation and a position with very little cooperation (Glance and Huberman 1994). The point in time for transition from one state to another is impossible to predict, but the relative frequencies for being in the respective states stabilise to fixed proportions that depend, loosely speaking, on how good the states are for the group (Young 1998, p 12).

The concept of hard uncertainty introduced by Dror (1988, p. 251) seems to be similar to this variety of structural uncertainty. According to Dror uncertainty is hard when it is "...structurally inbuilt into the dynamics of the phenomena, which behave, at least partly, in a chaotic, indeterminate and random mode from the perspective of present human thinking...".

The third case (C) is when there is a fundamental lack of understanding of the dynamics of a process. No mathematical model – predictive or not – can be meaningfully used. An example of case C is when a dominant technological regime, such as the internal combustion engine, is beginning to give ground to new technologies. Then, it is often difficult to get a grip of what is happening and to foresee which novelties will last and eventually take a dominant position. However, scenarios may often be based on opposing tendencies present today, by giving a dominant role to one or the other, or to (compatible) combinations of them. Sometimes the scenarios may inspire modelling work, eventually leading over to a situation similar to the first case (A).

van der Heijden (1996, pp 84 and 100-102), uses the term structural uncertainty in a sense that seems to be similar to case C. He divides uncertainty into three categories, viz. risk, structural uncertainty and unknowables. The difference between risk and uncertainty is that in the case of the former there is enough historical precedent to enable one to use (judgmental) probabilities of various possible outcomes, but this is not possible in the case of structural uncertainty. van der Heijden describes structural uncertainty in the following way:

“This type of uncertainty often arises when patterns in events can be interpreted in various ways. Based on these different structures, different futures will emerge. In such deep structural questions we will find ourselves mostly in entirely new and uncharted territory, with no history to base probabilities on.”

(van der Heijden 1996, p. 84)

The concept of unknowables is similar to that of unspecified uncertainty and opens the door for true surprises.
It should be noted that all three cases (A, B and C) of structural uncertainty identified in this section admit that uncertainty as regards the dynamics of a system be specified at least to a degree, and a way of doing it is by developing scenarios. In cases A and B it is even possible to set up different models or one model with multiple attractors, which is a potent way of structuring uncertainty. This presupposes a specification of variables involved. Of course, there may remain a residue of unspecified uncertainty and hence the possibility of surprise.

If there is a desire or a perceived need to change direction for a system among analysts and groups of citizens involved, e.g. because present trends are unsustainable, this may require more than the manipulation of the usual policy variables - it may require a change of the dynamics of the systems. Then, it is the possibility of structural change, as illustrated by cases A, B and C, that is of interest. Scenarios are potentially helpful in exploring trend-breaks and conditions for structural change.

1.3 Uncertainty and strategy: Static vs. dynamic uncertainty

There is a strong connection between the kind of uncertainty and the choice of strategy in planning. This is the main topic of a doctoral thesis by (Strangert 1974). Strangert developed a set of concepts for the analysis of uncertainty and strategies for coping with it in planning. His general framework is a modelling approach similar to that of Figure 1 above. Strangert’s focus of attention is on the case where a reliable model of the planning object exists. This means that uncertainty is confined to the development of external variables and the associated effects on output variables. However, he also acknowledges the case of unspecified uncertainty as mentioned above.

Although Strangert’s key concepts are developed for the analysis of uncertainty of external variables, I believe they are also applicable in the case of structural uncertainty. I therefore discuss three of them here, viz. static, quasi-static and dynamic uncertainty. Strangert defines these as follows:

**Static uncertainty:** “External inputs are said to be statically uncertain when, in planning, several alternatives are recognized as possible and when there is no indication that the uncertainty may change over time or that it can be affected (diminished).” (Strangert 1974, p. 25).

**Quasi-static uncertainty:** "... the form of uncertainty that can be reduced in a negligible period of time relatively to the decision alternatives." (Strangert 1974 p. 28).

**Dynamic uncertainty:** When uncertainty is expected to resolve over time, the planning situation is characterised by dynamic uncertainty. (Strangert 1974 p. 30).

In the case of static uncertainty, there is no point in waiting for more information. A one shot decision will work. If several outcomes of external variables – or changes of the system dynamics – are possible, a strategy that is reasonably good in all cases
should be sought. This is the strategy of flexibility, where the planning entity prepares for several preconceived possibilities.

In the quasi-static case, it may pay off to postpone the decision until a limited (in time) research effort has been carried out in order to resolve some of the uncertainty. After that the situation is similar to the static case.

Finally, when dynamic uncertainty prevails, the one shot decision is still possible, but it is often better to adopt a strategy of step by step decisions, where new knowledge is successively taken into account (the strategy of adaptability). One may also make preparations that increase the ability to adapt to new conditions (new information) that may arise later (Strangert 1974).

Another way of defining the concepts of static and dynamic uncertainty is suggested by a Swedish parliamentary commission (SOU_1969:25 1969, p. 18). Here, the concepts are defined in terms of the relationship between warning time and response time. Thereby the link between uncertainty and strategy is built into the very definition of the uncertainty concepts. In Eriksson’s wording (Eriksson forthcoming) “uncertainty is dynamic if the warning time is greater than the response time, otherwise static”. By making the distinction dependent on response time, the set of policy measures considered is brought into the limelight. Investments to reduce response time may change the uncertainty from static to dynamic and open the way for adaptive strategies.

When relating Strangert’s concepts to structural uncertainty as defined here, a few comments are worth making. First, structural uncertainty means that fundamentally different futures are possible. It may be more difficult to find a flexible strategy that can cope with different structures sufficiently well than to find one that is sufficiently good across variations within the same structure. In particular, when there is a need to build long-lasting structures, such as defence systems or transport infrastructure, this may be a problem. If uncertainty is of the static kind, it seems important to make efforts to shorten the response time in order to make uncertainty dynamic. This would open up for some adaptability even in a strategy of commitment to long-lasting structures (Eriksson forthcoming).

1.4 Structural uncertainty and the time-frame of planning
A natural question is: What systems are characterised by structural uncertainty and in what time-frame? I do not provide a general answer to this question, but a few comments are made below and an example of relevance to the studies presented in Papers 3 and 4 is given.

It is often reasonable to assume that present trends or dynamics will prevail for some time, even though in the longer perspective there is always the possibility of structural change of the system of interest. Hence, one hypothesis is that the predictive modelling approach is applicable in the short to medium term and scenario approaches in the long term. But is this always the case?
In some areas, development seems to alternate between long periods of stability and relatively short periods of rapid change and instability. During these “chaotic” phases, new patterns evolve and eventually dominate for some time, although these patterns are difficult to discern early on. A prominent example of a theory of this kind is that of the Kondratiev long waves (van Duijn 1983; Berry et al. 1993). During the erratic phases, new drivers and actors emerge and functional relationships change. New residential patterns, e-commerce and e-commuting may e.g. change the income elasticity of transport demand in the chaotic period of the emerging e-economy. In the face of structural uncertainty, several possible and structurally different developments need to be taken into account. A consequence of this line of reasoning is that predictive models may sometimes be inadequate even in the short term, because the system studied is currently in a stage of structural change, but its observed behaviour is difficult to interpret.\(^8\)

The dynamics of transport systems of big urban areas is an important issue in Papers 3 and 4, where the interest is to find transport patterns in line with sustainable development. I maintain that the development of this system over the long range is now characterised by structural uncertainty, after a long period of stability. Therefore, this example is presented and discussed at some length.

The development of car traffic, and before that railway traffic, followed a stable trend for a long period. It seems appropriate to speak of a lock-in as regards both vehicle technology and travel patterns. The internal combustion engine won the battle with the competing technologies and has dominated the market for a hundred years. It has developed, but basically it is the same concept. Now, other concepts are beginning to emerge again, such as hybrids that combine a fuel combustion engine with an electric engine or electric vehicles utilising fuel cell technology. Fuel cell buses are being tested in several cities today and many car manufacturers have development programmes for fuel cell cars.

Private car traffic has grown steadily in Sweden since the Second World War, except for a few years in the 1970s. It has been relatively safe to forecast continued growth. However, this trend too will eventually be broken. Trend-breaks are often related to shifts of technological regimes, as when the railway took over the leading role from the canals (Grübler 1990). These shifts may depend on the old technology having exhausted its potential to generate innovation and growth and its ability to handle new challenges. As it is losing momentum novel ideas will emerge, leading to new technologies and sometimes new behaviour. Today private car use causes congestion and health problems in big cities, and stands for a large share of CO\(_2\) emissions. Therefore, initiatives are being taken at various levels of society to find alternatives to the conventional car. At the same time, traffic planning in many cities

---

\(^8\) Energy forecasts in the 1970s frequently overestimated future energy use, probably because they were based on historical trends and patterns that were no longer valid (Svensson et al., 1984, p. 34).
still follows the traditional concept of predicting traffic increases and providing new infrastructure to meet the expected demand⁹.

The growing role of information and communication technology (ICT) is also changing the conditions for transport and, more generally, accessibility in a fundamental way. First, ICT can be used to integrate and coordinate different transport systems, such as light rail, bus, and rental cars. Transitions are smoother (seamless) and the traveller can get immediate information and guidance on the available options from point A to point B. This facilitates truly intermodal transport systems, which may lead to an optimal use of rail systems. Another example of the potential of ICT is efficient and convenient systems for road pricing, especially for trips into city centres.

In addition, ICT may also have an impact on the demand for transport, since it may yield accessibility without mobility. Today some people can work at home, linking up to their office via the Internet. In the future, this will be possible for an increasing number of information technology workers. In addition, it is possible to go shopping on the Internet and get the goods delivered. Whether this will remain a marginal phenomenon or grow into a considerable part of shopping is difficult to predict. The point is that ICT is making it possible for many people to organise their everyday life in new ways, including tele-commuting and tele-shopping. This may be the most important increase in freedom and flexibility for people for a long time. How it will be used remains to be seen. Admittedly, the new freedom may generate new trips, not just make trips unnecessary. Conditions are changing, with the emerging ICT offering accessibility without mobility, but also giving people and organisations broader networks that may work as drivers for new meetings and, hence, transport.

The bottom line is that at present there is a fundamental and structural uncertainty as regards the future development of private car use, especially in large urban areas. The lock-in may be breaking up and historic trends may not continue. Instead, there are several quite different possible paths into the future and public policy may have a pivotal role. In short, we are faced with structural uncertainty.

Another relevant issue is whether periods of stability are tending to become shorter and less stable. Godet (1979, pp. 11-12) argues that the speed of change in society has increased, making predictions more precarious. He also maintains that structural uncertainty is becoming more important.

Eriksson (forthcoming) also argues that there is some reason to believe that periods of stability will become shorter and less stable, but from a partly different perspective.

“It is, however, possible that the emerging ‘network economy’ has the potential to bring about a novel system of innovation where lock-ins tend to be weaker than in traditional industrial society. Key features in this regard include:

⁹ See e.g. Owens (1995) for a discussion of the policy of predict and provide.
• Standardisation – particularly in interfaces, with the Internet Protocol serving as an overall key to systems integration – enables novel technical systems to be put together very swiftly.
• Models and simulators are key tools in this, which also help in concurrently developing business architectures, training personnel etc.
• Many production factors are becoming available on rental markets and do not have to be meticulously built in house – outsourcing is a term covering some aspects of this.”

(Eriksson forthcoming)

If this is so, the need for scenario approaches will increase.

1.5 The case for gaming

In this study the focus is on systems where human agents - individuals or institutions - play an important role. Socio-technical systems is a common term (Hughes 1987). Here, an important aspect that has to be dealt with is the ability of the actors to reflect on the performance of the system and to adapt their behaviour in order to optimise the personal (or possibly the collective) yield from the system. Thus, there are usually feedback loops in the system, making the dynamics non-linear.

There is an important divide between large systems and small systems. In the former case, the actors perceive the system as impersonal, and adapt to the experiences gained but without the intention of changing the system. Yet the combined effect of actions taken by all actors has an impact on the system. In the case of small systems the personal contacts and interaction with other agents is judged to have an impact on the system’s behaviour and the pay-offs to the involved parties. Here it becomes rational to ponder on the intentions of other actors. These cannot be predicted with certainty. Instead, several possibilities often must be considered. Uncertainty related to intentions seems to be a pertinent term. Relevant planning tools are game theory and gaming.10

Ståhl (1988) uses the term game situation for this kind of non-linear dynamic system. In a game situation, according to Ståhl

“...there are several decision makers and the decisions made by each will noticeably influence the payoffs to some others. Thus, in a game situation there is an interdependence between at least two decision makers in the sense that neither can make any kind of optimal decision without first considering the decision the other side is likely to make.”

(Ståhl 1988)

10 Classical non-cooperative game theory typically deals with what I have called small systems (involving few actors). However in evolutionary game theory even large systems (involving many actors) are investigated, where actors play against the system as a whole.
Uncertainty of game situations has to do with difficulties in assessing the intentions of the other parties in the game. Usually, in a game situation the parties involved have at least partly conflicting goals. A player of the game may not know the other players’ goals or intentions. In addition, it is not easy to assess what tactics other players will use. This kind of uncertainty is typical for military planning, but also e.g. for firms acting on an oligopoly market. It is sometimes called antagonistic uncertainty. However, uncertainty related to intentions is a broader concept covering cases where the goals and interests of different parties are not totally antagonistic.11

*Game theory* and *gaming* are two ways of coping with game situations. When outcomes and strategic options are well-specified, then game theory provides an analytical tool (cf. the example on social dilemmas discussed in Section 1.2). *Gaming*, on the other hand, can cope with the case of not well-defined options and outcomes that are difficult to quantify or even specify. Paper 1 explores the potential for gaming in crisis management preparations and exploration of game situations.

### 1.7 Summary

I have argued that sometimes planning should take structurally different futures into account – i.e. futures different from today and different from each other.

One reason is that in many contexts, and possibly increasingly so, uncertainty of the development of the system studied is structural, which means that new dynamics are possible. Possible roots of structural uncertainty are:

- the possibility that new external factors emerge with an unexpected influence on the system;
- the possibility of conceiving several different dynamics of the system;
- unpredictability due to e.g. sensitive dependence on initial conditions;
- a lack of understanding of the long-term behaviour of a system (even in the absence of new external drivers).

This kind of uncertainty is mainly of importance in long-term planning, but could be so even in a shorter time frame if the present situation is characterised by rapid change.

Another reason for studying structural change is that present trends may be unsustainable and political efforts to break them will have to come sooner or later. Then it could be of interest to explore more favourable developments and conditions, and measures that would facilitate a change of direction.

Finally, when it comes to developing the skills needed for coping with new and partly unexpected situations, gaming is a useful tool. In particular it is of relevance in the face of uncertainty related to intentions. Paper 1 analyses applications in civil emergency planning and crisis management.

---

11 Eriksson (forthcoming) uses the term intentional uncertainty.
In the following chapters, approaches for exploring the future adapted for these kinds of situations are presented and discussed.
2. Exploring the future

There is a rich variety of perspectives and methodologies used for the exploration of the future. Besides giving a brief overview of the field since World War II (Section 2.1), this chapter categorises futures studies according to three modes of thinking about the future and related methodological approaches to futures studies (Section 2.2). I also discuss the grounds on which a choice of approach can be made.

2.1 Brief history of futures studies

It is typical of Man to relate to the future in a conscious way. We ponder over what may happen and how we can cope with it if it happens. We also (sometimes) act intentionally with a long view. While some animals can plan how to fulfil present needs, Man is the only species that can consciously plan for future needs (Gärdenfors 2000, p. 19). The endeavour to foresee coming events and to form visions of better worlds can be found throughout the history of mankind. However, systematic studies of the future with the aim of informing debate and decision-making in society are essentially a post World War II phenomenon.

Perhaps the most influential branch of futures studies has grown out of the Operations Research (OR) and Systems Analysis (SA) tradition. This holds for Sweden as well as internationally (Kajser and Tiberg 2000; Ingelstam 2002, pp. 251-253; SOU_1986:33 1986). This tradition has its roots in strategic planning within the military-industrial complex, and with the American think-tank RAND in a leading position (Cornish 1977, p. 83 ff). Initially the focus was mainly on technological developments with potential implications for national security, but in the 1960s and 1970s futures studies attended to society in general or some constituent sector. A famous example is The Year 2000 by Kahn and Wiener (1967). During the 1970s, many studies focusing on the energy system came into the limelight due to the oil crises.

An influential institute closely related to the OR/SA tradition is the International Institute for Applied Systems Analysis, IIASA, at Laxenburg in Austria (Cornish 1977; Svidén 1989, p. 248 and 23 respectively). The Institute was promoted by several Western countries as well as by the USSR, and worked as an intellectual meeting place for researchers from the Soviet block and the Western democracies during the Cold War. IIASA has an orientation towards interdisciplinary scientific studies of environmental, technological and social issues on the global scale, and with a focus on the long-term development of complex dynamic systems. Several studies employ the logistic S-curve to analyse the different phases of market penetration of technologies and infrasystems, and the transition from one dominant technological regime to a new one (Grübler 1990; Grübler and Nakicenovic 1991).

In Sweden the National Defence Research Institute (FOA)\textsuperscript{13} had a leading role in OR, SA, and the development of a long-term planning system for the defence sector (Jennergren, Schwartz and Alvfeldt 1977; Kajser and Tiberg 2000). Furthermore, the FOA school made contributions in planning and uncertainty (Strangert 1974) and scenario methodology (Schwartz 1988). Subsequently personnel with experience from FOA entered the Secretariat for Futures Studies founded in 1973. Lars Ingelstam headed the Secretariat and Peter Steen had a leading role in energy future studies during the 1970s and 1980s (Lönnroth, Johansson and Steen 1978; Lönnroth, Johansson and Steen 1980). Since the early 1990s, futures studies on sustainable transport (Banister et al. 2000) and work similar to scenario planning in the Shell tradition, mainly for public sector clients (Eriksson forthcoming), have been carried out by FOA, often in cooperation with other institutes and universities in Sweden and other European countries.\textsuperscript{14}

Future studies also spread to the private sector, where some big companies used scenario methodologies to cope with the uncertainties of their changing environment. Here, Shell had a leading role in developing processes designed to guide actual decision-making and strategy forming (Wack 1985a; Wack 1985b). The Shell approach is discussed below.

In France, the school of \textit{la Prospective} was developed by Berger (1967), Godet (1979)\textsuperscript{15} and others. This approach was developed because of the alleged shortcomings of traditional forecasting, by which was meant predictions based on quantitative modelling (Godet 1979, pp. 10 – 19). The prospective approach is holistic, mainly qualitative (using cross-impact analysis and other formal techniques) and takes structural change into account. Another typical feature is the strong emphasis on Man's ability to shape the future, at least in the long run. The future is partly pre-determined, but there is considerable scope for our free will. Another influential French contribution of a more philosophical kind is The Art of Conjecture (Jouvenel 1967).

Partly as a reaction to the dominant approach with its top-down perspective and emphasis on technology, a more socially and economically orientated approach, often critical of dominant trends in society, appeared in the 1960s and 1970s. \textit{The Limits to Growth} being a prominent example (Meadows et al., 1972). This work applies a truly global perspective to development. Population growth, production, consumption, resource use and environmental impacts are modelled as a dynamic system with feedback links. The report predicted that the limits to growth of \textit{the present kind} will be reached within 100 years with a sudden and uncontrollable decline in population and industrial capacity as a result. The solution entails slowing down growth rates to a sustainable level. The report was much criticised for being alarmistic but also had an important role for the emerging environmental movement. Even more important in this respect, however, was \textit{Silent Spring} (Carson 1962).

\textsuperscript{13} FOA and FFA 2001 merged into the Swedish Defence Research Agency (FOI)

\textsuperscript{14} The author has been involved in both kinds of studies.

\textsuperscript{15} The French original was published in 1977.
Of special interest is a tradition that emphasises the role of images of the future for the intentions and actions of Man. Pioneering work by Polak (1973) inspired several works by others with a critical eye on prevailing images of the future and present conditions in society. Polak stressed the potential of optimistic and utopian images of the future to inspire dedicated action. A study in the key of Polak was performed in the early 1980s by Elise Boulding and Warren Ziegler (Boulding and Boulding 1995, pp. 93-116). They held a series of workshops with people mainly from the peace movement in order to develop images of a world without weapons and related action scenarios. An aim was to stimulate action among those involved in the workshops. A more descriptive work on the role of images of the future is Laginder (1989), who analyses prevailing images of the future among participants in three governmental commissions in Sweden.

During the past 10 years or so, foresight has been used as a label for futures studies that mainly explore challenges (both opportunities and threats) connected with the technological development (Clayton, Wehrmeyer and Ngubane 2003; Wehrmeyer, Clayton and Lum 2002). Several countries have recently carried out national technological foresight studies, e.g. the UK, France, Austria, Germany, Sweden, Portugal, the USA and Japan. The interest in the potential of new technology forms a link to the early technology forecasting activities in the USA, but the approach is broader and less deterministic. According to a definition by Wehrmeyer, Clayton and Lum (2002, p. 29), foresighting is a deliberative process that involves the evaluation of many possible, desirable or feasible scenarios in order to develop a better understanding of options. Furthermore, the development of an action plan for the attainment or avoidance of particular scenarios is also part of a foresight process.

In Sweden the systems analytical approach, with its roots in the early efforts at RAND, and more socially orientated approaches, entailing critique of prevailing socio-technical regimes, have sometimes been combined (Lönnroth, Johansson and Steen 1980; Kajser, Mogren and Steen 1988).

Today, there is a rich variety of futures study approaches, reflecting different aims and interests and the characteristics of different fields of application. Van Notten et al. (2003) give an overview of existing forms of scenario approaches.

2.2 Three modes of thinking about the future

It is possible to discern three classical or even archetypal modes of thinking about the future. To each of them there are related futures study methodologies, which are elaborate and systematic ways of utilising the basic modes of thinking.

---

16 The original Dutch version was published in 1955.
17 The modes of thinking discussed in this section are similar to three kinds of attitudes to the future analysed in SOU_1986:33 1988, pp 11-14. A distinction between probable, possible and preferred futures is often made (Bell 2002; Marien 2002).
Thinking in terms of predictions (the predictive mode of thinking) is a long tradition, dating back at least to antiquity. The idea is to realise or at least get an indication of what will happen in order to be better prepared. A pre-scientific approach was to rely on divine revelation or to try to detect and interpret hidden signs of what was to come. Astrology, prophesies and the oracle of Delphi are early examples. With the emergence of modern science (e.g. Galileo and Newton) scientists started to develop mathematical models based on systematic empirical observations. The aim of these models was to explain the observed patterns with reference to general "laws of nature". The models could also be used to predict future events, such as eclipses (this had been done before, but with less accuracy). This approach has been very successful, especially in the natural sciences. However, predictive modelling also has a role in the social sciences and planning, e.g. economic forecasts and traffic forecasts. There are still many phenomena in nature as well as in society that are not fully understood or that are too complex to be predictable. This notwithstanding, predictive modelling is a widespread futures study methodology, similar to but more systematic and elaborate than the ancient endeavours to foresee coming events in order to cope with them in a better way. This is forecasting in a narrow sense, where one tries to find essentially one track into the future – possibly with minor variations. Besides predictive modelling, extrapolation of trends and some essentially qualitative methodologies such as Delphi (described in the next section) should be seen as examples of the predictive mode of thinking. They all try to find the most likely development.

Thinking in terms of eventualities, i.e. several different possible events or developments (the eventualities mode of thinking) is another approach to the future. The eventualities mode of thinking is characterised by the openness to several different developments. Again, the point is to be better prepared to handle emerging situations, but one realises that it is not possible to say what will actually happen. In modern times this mode of thinking has been systematised in the form of explorative scenarios. The American Think-Tank RAND and Royal Dutch/Shell have made important contributions to the development of scenarios as a tool for strategic analysis (see Chapter 3). Shell calls their approach scenario planning. The exploration of several different developments, including trend-breaking ones, makes the development of explorative scenarios a forecasting methodology in a broad sense.

To think in terms of visions (the visionary mode of thinking) means to envisage how society at large, some sector of it or some activity (private or public) could be designed in a better way than its present mode of functioning. According to Gärdenfors (2002), the human language may have developed because it increased our ability to cooperate in new ways. Our language helps us to create common visions that we can try to realise. This makes it possible for Man to share goals that are not immediately given by the present needs and the actual situation. As mentioned above, Polak (1973) argues for the importance of visionary images of the future to inspire coordinated action. Many great thinkers throughout history have suggested visions of a better society. Plato's The Republic is probably the first written example. Other early examples are Thomas More’s Utopia and the so-called utopian socialists’
visions of a better society during the Nineteenth Century. These authors all wanted to reshape society in a fundamental way, but paid little attention to ways of making it happen. Out of this tradition a corresponding futures study methodology has arisen. It is sometimes called backcasting and was launched in the 1970s in energy futures studies. Even earlier, the defence sector in Sweden used a similar methodology in its strategic planning process. Although the ambitions are modest compared to those of Plato or More, the idea is to suggest solutions to a fundamental societal problem and to take visionary goals into account. In contrast to the early visionary thinkers, in backcasting the exploration of paths leading to the goals is an important part of the study, as are systematic validations of the scenarios.

In futures studies, typically one of the modes of thinking and a related methodology are dominant and give the study its character. Usually, rational arguments could be given for the actual choice. Of special relevance are the kind of uncertainty characterising the system of interest, the goals of interest, the degree of influence of the targeted user on the system being studied and whether the aim is to guide actual planning or to inform the general debate and stimulate further research. These aspects will permeate the discussion of the following chapters.

2.3 Combined methodologies

Even though one approach is dominant, sometimes a complementary technique stemming from a different perspective is useful. When e.g. developing several structurally different scenarios (the eventualities mode of thinking), one should bear in mind that some phenomena may be possible to predict within reasonably narrow limits. Thus predictive methods may be used to handle a segment of the phenomena studied, without changing the general character of the study. Likewise, in a backcasting study, a predictive modelling approach could be (and usually is) used in order to assess the likely consequences of a trend-like development as a part of a problem setting phase (Højjer and Mattsson 2000). The main character of the study is still backcasting. In such cases one mode of thinking is dominant, but methods or techniques usually associated with a different mode of thinking may be adapted to the actual framing of the study.

Sometimes, however, methodologies representing different modes of thinking are combined on a more equal basis. This may happen when key determining factors for choosing one or other approach do not lead to a clear verdict. One may be interested in visionary goals (speaks for backcasting) but want to use the results in an actual planning context to guide decisions (speaks for scenario planning). Then it could be a good idea to combine the two approaches. In such cases one could say that two

---

18 See (SOU_1969:25 1969). The approach of the Swedish defence was actually a mix of an external scenario approach and backcasting. Future possible threats to Sweden were presented in the form of external scenarios. Goals were defined for the ability of the defence to meet the threats, and then future defence structures were worked out and steps on the way to these structures were defined. This was the backcasting part.
modes of thinking are combined, not just different analytical techniques. The whole perspective transcends that of a single mode of thinking.

It is my impression that the pure forms of futures studies are by far the most common ones. In a recent survey of futures-relevant literature, Marien (2002) classifies studies according to purpose. He uses 6 categories, namely probable futures, possible futures, preferable futures, present change, panoramic views and, finally, questioning (the others). The first three are similar to the modes of thinking defined above. Marien maintains that the great majority of futurists think in only one or, at most two of the categories (Ibid., p. 272). Many scholars tend to keep to one of the modes of thinking, and I am not convinced that there are only instrumental reasons for this. Personality and scientific or professional training may be equally important factors. It may also be effective from the point of view of intellectual clarity to use a consequent and clean cut perspective. However, the complexity of the task sometimes speaks for a mixed approach.

In this study two cases of mixed approaches are included. Paper 3 gives an account of a combination of predictive modelling and explorative external scenarios. Paper 4 describes a methodology that combines external scenarios with backcasting.

2.4 Predictive modelling

The predictive modelling approach is based on the idea that it is possible to model how some part of reality works, e.g. passenger transport in an urban area (cf. Section 1. 2). The model has to capture the essentials of the logic governing the process of interest in order to be useful. Given data on the initial state and assumptions about the development of some external variables, the model can predict the development of the modelled system for a given period of time. As mentioned above, mathematical predictive modelling has been a very successful activity in natural sciences. The role of predictions in the social sciences is much debated and I shall not try to cover this complex issue. Suffice it to say that predictive modelling is actually used in e.g. economics and urban studies, mainly for short to medium term forecasts. (Makridakis, Wheelwright and Hyndman 1998) provides an overview of forecasting methods.

Forecasts, as a rule, are conditional, i.e. they are based on a set of assumptions. As an example, traffic models often build on assumptions of how incomes will develop. Household incomes are an important external variable influencing transport demand. Variations of GDP therefore yield different prognoses of traffic. Some analysts call these scenarios. There is a fundamental difference, however, compared to the scenarios of scenario planning. The latter are used to map structurally different futures, whereas forecasts with variations of external variable values all pertain to the same kind of structure.

---

19 A prominent example of a mixed methodology is the prospective approach, which combines exploratory and visionary elements (Godel 1979, p. 24-25).
Some forecasts pertain to processes that the user of the prognosis cannot influence. An example is weather forecasts, which are not made in order for people to try to change the weather. Instead, the idea is that one can adapt to what is likely to happen – e.g. by cancelling a sailing tour or buying an umbrella. In planning, however, models are sometimes used to test the outcome of various policy measures. Then a few policy variables are defined, e.g. various kinds of taxes, fees or rebates. These are externally determined by the user of the model (see Figure 1 in Section 1.1). By running the model, a policy analyst may explore the impact of different policies on variables of special interest, so-called goal variables. An example would be a model that calculates the rate of unemployment as a function of several economic variables and a few externally determined policy variables. Such models are typically used for short-term analyses (a few years).

Often, predictive approaches operate without a formal model of the system of interest. Instead historical data are used to extrapolate an observed trend into the future, sometimes based on sophisticated statistical methods (see Makridakis, Wheelwright and Hyndman 1998). However, the underlying dynamics are not penetrated in such cases.

Forecasting technological change poses a problem for the predictive modelling approach as well as for the trend extrapolating approach. No reliable model can be found and historical data are of little value. In the terminology of Section 1.2, such a situation is characterised by structural or even unspecified uncertainty, and the eventualities mode of thinking would seem to be more relevant than a predictive mode. Nevertheless, for this situation a qualitative methodology, based on expert opinions, was developed by the RAND analysts Olaf Helmer and Theodore Gordon in the 1960s - the Delphi methodology (Cornish 1977, p. 85). As in predictive modelling the idea is to find the most likely development. Experts are chosen to form a panel and individually express their opinions about the future in an iterative process with controlled feedback, eventually converging to a consensus scenario. This is then understood as the most likely development. The classical Delphi, apparently, is an example of the predictive mode of thinking. However, there is a variant of Delphi where after the first round experts with similar opinions are grouped together. The feedback about other experts’ views is then contained within each group. In this way the convergence appears group-wise, leading to a set of different scenarios (Best, Parson and Rosenhead 1986). This variety of Delphi is an instance of the eventualities mode of thinking.

---

20 The use of the (original) Delphi methodology in situations with changing patterns has been criticised for forcing a consensus on the most likely development when the spread of opinions as regards possible developments should be the most interesting aspect (Asplund 1979, pp. 73, 78-80). This is actually an argument for applying the eventualities mode instead of the predictive mode of thinking.
2.4 The case for scenario approaches

Chapter 1.2 described how in the presence of structural uncertainty, several fundamentally different futures are possible. No single reliable forecasting model can be found for the time frame of interest. As stated in Section 1.4, the development of urban passenger traffic beyond 2015 may be an example of this.

The conclusion to be drawn is that the predictive mode of thinking – i.e. the search for the most likely development - is less relevant in the face of structural uncertainty. Instead, the eventualities and the visionary modes of thinking are better adapted to this situation. This entails developing sets of structurally different scenarios that can help planners choose robust or adaptive strategies.

Two comments should be made. First, the eventualities mode of thinking does not preclude the use of quantitative models. Models representing (partly) different system dynamics may be developed, based on qualitative scenarios. Second, some aspects of a system may be possible to predict with reasonable accuracy, although other parts are not. As an example, demographic trends tend to be relatively stable. In such cases a predictive approach could be used for part of the system, while the system at large is explored with the help of scenarios.
3. Two scenario approaches

In this chapter, two scenario approaches are presented – scenario planning of the kind developed by Shell and backcasting. They represent the eventualities mode and the visionary mode respectively. Many other scenario methodologies exist, and I touch upon some of them, but the focus is on these two because they have inspired the methodologies applied in Papers 3 and 4.

Probably, the first use of scenarios was for military purposes of training and operational preparations, often in connection with gaming (von Reischitz 1988, p. 11). A large step forward in the development of scenario methodologies was taken by the American think-tanks RAND during the 1950s and the Hudson Institute during the 1960s, with Herman Kahn as the leading personality. Kahn and his colleagues developed sets of different scenarios with the explicit aim of widening the thinking about the future, which is important for policy-making. The following citation summarises their view of the role of scenarios and clearly shows that this is an instance of the eventualities mode of thinking.21

“We are also trying to put policy-makers in a position to deal with whatever future actually arises, to be able to alleviate the bad and exploit the good. In doing this, one clearly cannot be satisfied with linear or simple projections: a range of futures must be considered. One may try to affect the likelihood of various futures by decisions made today, but in addition one attempts to design programs able to cope more or less well with possibilities that are less likely but that would present important problems, dangers or opportunities if they materialized.”

(Kahn and Wiener 1967, p. 3).

The scenario studies at RAND and Hudson Institute were carried out by a multi-disciplinary research team (the term think-tank is often used as a label for these and similar institutes or groups) and some were presented in books directed towards an interested public of scientists and policy analysts. In such cases the aim was to inspire futures thinking generally rather than to guide actual policy making of a specific organisation.

Around 1970 Royal Dutch/Shell took an important step by integrating scenario development and the use of scenarios into the strategic planning of the company (Wack 1985a; Wack 1985b; van der Heijden 1996). The term used is scenario planning. Inspired by Kahn, Shell adopted the idea of a set of different scenarios (the eventualities mode of thinking) but added a process for the making of scenarios that involved the intended users, usually people from several management levels of the

---

21 Jouvenel (1967) is on the same line and strongly argues for the use of a fan of possible futures, and launched the concept futurible, which is a combination of future and possible (ibid. pp. 16-19).
company. The format for this was workshop exercises with elements of brainstorming and clustering of ideas. The aim was that the scenarios, due to the participative approach, would be accepted as relevant, intriguing and plausible by those using them. The scenarios were then used as tools for development and assessment of strategies.

Shell developed the scenario planning methodology for its own needs. Other big companies have followed their example and a consulting network, Global Business Network (GBN) has specialised in conducting the process of scenario development and use, mainly for business clients.

Two aspects of these scenario studies stand out as important. The first has to do with the kind of aim and addressee of the study. It could either be to inspire a broad audience or it could be to guide policy making and planning of a specific organisation. In the latter case there is a well-defined “problem owner”, for whom the work is done and who intends to use the results. The second aspect concerns the process for making scenarios. They can either be made back-office by a project team (the think-tank model) or be made in a participative process that involves the targeted users of the scenarios (the participative model). Clearly, these aspects are interrelated. The aim of guiding policy-making requires the participative model (van der Heijden 1996, pp. 117-118). But does the inspirational kind of study require the think-tank model? This seems less obvious. If there is no client organisation that owns the results, the role of a panel will not be the same as in the Shell/GBN kind of study. However, there are examples of studies that, although essentially of the think-tank variety, systematically use workshops with panels of experts (Masser, Svidén and Wegener 1992; Snickars 1999). In these cases the point is to improve the quality of the scenarios by bringing in more expertise, either to capture ideas early on or to evaluate and improve on preliminary results.

During the 1970s, backcasting studies started to emerge (the visionary mode of thinking). They typically addressed a perceived societal problem with the aim of finding a real solution. Examples are studies of the energy system and how it could be designed without use of fossil fuels and/or nuclear power. These studies were clearly addressed to a wide audience and the think-tank model characterised the work. In recent years, there has been a clear tendency to involve stakeholders in backcasting studies (Quist forthcoming; Robinson 2003). These are sometimes called participative backcasting, and can either involve mainly expert groups (Hojer 1997; Green and Vergragt 2002; Metz et al. 2003), or grass-root movements and ordinary citizens in the tradition of Elise Boulding (Boulding and Boulding 1995; Carlsson-Kanyama et al. 2003). In the context of Strategic Environmental Assessment (SEA), there are attempts to integrate backcasting into planning processes in order to guide strategic decision-making of a specific planning entity (Noble 2000). There are also examples of backcasting being used in corporate strategic planning (Stewart 1993).

Table 1 summarises the discussion about different aims and working processes of scenario studies.
\begin{table}
\centering
\caption{The design process and the mode of futures thinking (explorative or normative) related to the aims of the scenarios}
\begin{tabular}{|l|l|l|}
\hline
Process for developing scenarios & Kind of scenarios & Explorative & Normative (visionary) \\
\hline
Think-tank model & Aim: Inspire thinking in terms of eventualities in society at large or in academia & Aim: Inspire visionary thinking and debate in society \\
a) Pure form & Examples: RAND (type a) and several academic studies (type b) & Examples: The Secretariat of Futures Studies and FOI/fms in Stockholm (type a) and the COOL project (b) \\
b) Supported by external expert panels & & & \\
\hline
Participative model & Aim: Guide pragmatic policy making & Aim: Inform visionary policy making and inspire action & \\
& Examples: Shell/GBN, FOI, Batelle Institute & Examples: SDRI in Vancouver (Robinson) A world without weapons (Boulding) & \\
\hline
\end{tabular}
\end{table}

An important distinction is that between external scenarios and policy scenarios. External scenarios deal with the development of factors outside the control of the intended user of the scenarios – e.g. a company or a public decision-maker. These factors should also be salient to the activity being planned. As an example, the crude oil price is an external factor to a haulage contractor. The firm has no influence on the price, but it affects business and profits. External scenarios are typical of e.g. the Shell approach, which is described in the next section.

Policy scenarios, on the other hand, include the use of policies for coping with the issue at stake. As an example, scenarios intended to highlight possible developments of urban transport should be seen as policy scenarios if they entail transport policy measures available to urban planning. If the scenarios only cover other policy areas, they are instead external scenarios. Backcasting studies produce a special kind of policy scenario, namely those leading to a predetermined visionary goal. However, policy scenarios may also be of an explorative kind. These may be used to assess the long-term effects of different sets of policies on variables of interest (such as economic growth or levels of CO₂ emissions). Examples are (Masser, Svidén and Wegener 1992; Snickars 1999). It seems that external scenario approaches are closer to actual decision-making, while policy scenarios often are made for a broader public and with a general inspirational aim.
In the following sections, scenario planning and backcasting are briefly described and compared.

3.1 External scenarios for strategic planning

A very clear application of the eventualities mode of thinking is the scenario planning tradition developed by Shell (Wack 1985a; Wack 1985b; Schoemaker and van der Heijden 1992; van der Heijden 1996).

As mentioned above, in scenario planning external scenarios are developed and used. It should be noted that the distinction between external and internal made in relation to a model-based approach (see Section 2.2, Figure 1) is not identical with that made in scenario planning. The former defines factors as external when they are not determined within the system being modelled. Here policy variables accessible to the planning entity may, consequently, also be regarded as external. In scenario planning policy options are regarded as internal, while factors beyond the control of the planning entity are external. Shell and GBN use to make a distinction between two kinds of external factors, viz. the transactional environment and the contextual environment (see Figure 2).

![Figure 2. The inner oval is the area of internal factors, where the planning entity has control. Outside this area are external factors, either in the transactional field, where the planning entity interacts with other parties or in the contextual field, where the planning entity has no or marginal influence. (Source: Eriksson forthcoming)](image)

The aim of scenario planning is to make a strategic analysis of the options that are open to an actor. These options are assessed against external scenarios in an effort to find a combination of policy measures (a portfolio) that yield a fair outcome in all or most of the scenarios. This is the idea of robust or flexible planning. The scenarios may also give rise to novel strategic ideas. Often strategies and measures are continuously evaluated and adapted according to experiences gained. This is called adaptive planning. External scenarios may also make it easier to realise emerging patterns in the firm's environment. van der Heijden (1996, p. 18) maintains that Shell, thanks to its scenario planning, foresaw the first oil crisis 1973 as a possibility. Because of the scenario designing activities, Shell saw the signs of an emerging crisis.
It also led to changes of the investment plans, with a higher share of downstream investments because of the lower vulnerability to increases in crude oil prices (van der Heijden 1996, pp. 18-19). Shell also established a trading unit to be able to operate on the spot market. The first move meant a commitment to a production structure. The choice was based on an analysis of several scenarios with the aim of working sufficiently well across the set of scenarios. The second move cost little but added to the firm’s capability to cope with a crisis. It was a strategy of adaptation and opportunity seeking.

Three important aspects/criteria of the scenario building are:

1. All scenarios must be relevant to the planning object. If two scenarios have similar effects in this respect, one should be omitted;
2. The scenarios should be challenging (there could be one business as usual scenario, however);
3. The scenarios should be plausible (possible). This entails internal consistency. They need not be probable, however.

The set of scenarios should span the credible space of uncertainty. There is a tension between points 2 and 3, however. If the scenarios are not challenging enough, they are of little use, as the aim is to stimulate a broader perspective in strategic planning. If, on the other hand, they are too challenging, they may not be accepted as plausible.

Many enterprises have followed Shell and applied its scenario approach to their strategic planning. The approach has also been used in public sector planning, e.g. in the Swedish technology foresight (Eriksson and Stenström 1999), and in strategic planning for the railway sector in Sweden (Eriksson 2000). A recent example from the European level is the STEEDS project (see Paper 3).

As mentioned in the introduction to scenario approaches above, it is typical for the scenario planning tradition to use panels in the scenario development process. Participants in workshops are representatives of the client organisation, often from several management levels, and sometimes some external “remarkable people” (van der Heijden 1996, p. 10 of the Preface). A broad participation is seen as very important in order that the scenarios be accepted by the users. Their participation also adds to the quality of the scenarios. Two forms of scenario generation methodology are the deductive and the inductive modes. In both cases salient and uncertain external factors are first identified and clustered into aggregates. In the deductive case a suitable framework for the set of scenarios is then developed. Usually a 2X2 matrix is used, where the two dimensions are based on external factors with a high rating as regards importance and uncertainty. For each square of the matrix a scenario is developed. In the inductive case, scenarios emerge from a

---

23 Personal communication with van der Heijden, Feb 2003.
24 van der Heijden (1996, p. 187), has essentially the same criteria, although broken down to a more detailed level.
24 The workshop methodology is similar to the kind described in Eden and Ackermann (1998).
process where participants work out story lines, which are subsequently clustered into coherent bundles (van der Heijden 1996, p. 196).

Of course, the Shell-GBN approach is not the only methodology for developing scenarios for policy development. Some other approaches, although essentially qualitative like the Shell methodology, use systematic combinations of variable states with the help of computer software (von Reibnitz 1988; Ritchey 1997; Gausmeier, Fink and Schlake 1998). Although some of these traditions build on the Shell methodology, they all emphasise the need for a systematic or formal method – as opposed to the “intuitive” approach of Shell and GBN (Gausmeier, Fink and Schlake 1998, p. 122) and traceability of the intellectual path leading up to a set of scenarios (Ritchey 1998, p. 9). Despite some apparent similarities, it does not seem adequate to speak of one tradition, because different groups make little reference to each other’s work. Nevertheless, I use the term formal approaches as a common label for these methodologies.

What then, is the main difference of the formal approaches as compared to that of the Shell-GBN methodology? First, it is a systematic combinatorial approach to building scenario skeletons from elementary parts (possible future states of external factors/variables). Second, it is a selection procedure for arriving at a manageable number of scenarios picked out from the usually very large set of scenario skeletons. This selection is to a large extent based on inner consistency. Both steps require computer software that can handle the huge amount of data. The Shell-GBN methodology is more intuitive (much like an art) when it comes to going from parts (e.g. external factors) to wholes (scenario outlines, structure of scenario space).

As for the consistency check used by von Reibnitz, Gausmeier and Ritchey, this is based on pair-wise assessments of variable states. However, the compatibility of two variable states may depend on the wider context, i.e. on the scenario at large – and this is not decided until a later stage of the process. Therefore, it is unclear what assumptions about the context are made by the experts when they make a judgement. If it is a business as usual kind of world, this could lead to overcautious judgements. In order to cope with this difficulty, in Ritchey’s approach the participants are asked if they can conceive of any situation where the combination is possible. If the answer is yes, the combination will pass the test.

Another difference is that while both approaches are participative, the Shell-GBN scenario generation process can accommodate a larger number of participants – 15 to 30 is common. The formal, computer-based methodologies are not efficient when the number of participants exceeds 8-10 persons.

The approaches discussed above all aim at guiding strategic decision-making of a specific planning entity or sector. In academic contexts, scenarios are used in futures studies, yet with a more indirect connection to policy making. Hence, the aim is more

---

25 Personal communication, Dec 2002.
of the inspirational kind (see Table 1 above).\textsuperscript{26} Even in research orientated studies carried out by research teams, broader panels are often used, either for generation of ideas or for elaboration and critique of outline scenarios or for validation. The first variety may be labelled bottom-up, while the latter is top-down. Sometimes there are several iterations between the project team and the panel, blurring the distinction between bottom-up and top-down. The STEEDS project essentially applied a bottom-up approach. The Geography of Europe’s Future – a study within NECTAR\textsuperscript{27} – is an example of a top-down approach (Masser, Svidén and Wegener 1992). Another example of a top-down study is that of Snickars (1999).

3.2 Backcasting

One of the first to write about the backcasting methodology was the Canadian researcher John Robinson (Robinson 1982), who has performed several backcasting studies in the field of energy and environment.\textsuperscript{28} Robinson describes backcasting in the following way:

“The major distinguishing character of backcasting analysis is a concern, not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backwards from a particular desirable future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point.”

(Robinson 1990)

Instead of making projections from the present into the future, in backcasting one starts by designing \textit{Images-of-the-future} that show how a solution to a major societal problem might look. The time horizon is sufficiently far off to permit real change to take place. This is a means to free oneself of the burden of present trends, making it easier to find interesting options. In fact, this is one of the most prominent advantages of backcasting. When Images-of-the-future have been developed and validated as to their feasibility, one tries to find one or several paths leading from the present situation to the Images. The role of policy-making is highlighted.

The backcasting approach can be described by the following three steps\textsuperscript{29}

- **Step 1. Scoping and choice of criteria and targets.** This step also entails an analysis of the problem with present trends. Could the prevailing dynamic eventually lead to fulfilment of the targets? If not, the main obstacles are identified.

\textsuperscript{26} A brief survey of scenarios in the field of transport and energy is given in Appendix 2 of Paper 3a.
\textsuperscript{27} NECTAR is the acronym for Network for European Communications and Transport Activities Research.
\textsuperscript{28} Other sources on backcasting methodology are Höjer and Mattsson (2000) and Paper 2.
\textsuperscript{29} Developed from Åkerman et al. (2008).
• **Step 2. Development of Images-of-the-future.** One or several Images-of-the-future are designed to meet the targets set in step 1. The Images are tested as to their goal fulfillment but also as to their attractiveness, feasibility and inner consistency.

• **Step 3. Analysis of paths to the Images.** One important question is whether there is a need for trend breaks of some kind and how these could be stimulated by policy measures.

Usually, the steps do not follow in strict consecutive order. Lessons learned in e.g. step 3 may lead to a partial revision of an Image (step 2).

Early examples of societal backcasting studies are a series of Swedish energy futures studies (Lönnrot, Johansson and Steen 1980; Johansson et al. 1983; Kajser, Mogren and Steen 1988; Steen et al. 1992). Energy systems have remained a field of application, a recent example being Azar et al. (2001). In the 1990s several backcasting studies of sustainable development have been carried out. A recent example is the OECD project Environmentally Sustainable Transport (EST) where several member states performed parallel backcasting studies (OECD 1997; OECD 1999). Other examples of applications on sustainable transport emanate from a Swedish research programme (Steen et al. 1997; Steen et al. 1998; Åkerman et al. 2000), a British study (Peake 1994; Peake and Hope 1994) and a Dutch project (Metz et al. 2003). The latter involved expert panels in recurrent workshops.

### 3.3 Comparative discussion of the scenario approaches

In this section, the two scenario approaches, external scenario planning and backcasting, are compared as to their aim, targeted users and competitive advantages and possible drawbacks in different contexts. The issue of scenarios and power is also discussed, i.e. the potential influence scenarios may have on opinions and decisions.

The most apparent differences between the two approaches are

* that the scenarios in scenario planning focus on factors beyond the control of the user of the scenarios, while in backcasting the scenarios focus on what is possible to affect;

* that external scenarios describe possible developments that are normatively neutral, while backcasting scenarios are normatively loaded.

External scenarios form a contextual framework for strategic conversations (van der Heijden 1996). Backcasting scenarios describe interesting or desirable Images-of-the-future and policy packages that are likely to lead to the images. When is the one approach to be preferred to the other? The answer has to do with the aim and the targeted user of the scenario study.
The aims differ
The aim of scenario planning is to improve the strategic planning of a firm or an organisation, by broadening the spectrum of possible future environments taken into account. The scenarios are thus a way of coping with the uncertainties of the external world. The goals of the planning process are typically pragmatic or opportunistic, such as survival of the firm, future expansion or higher profits. The scenario-based development of strategy may result in concrete decisions or actions, as e.g. when Royal Dutch/Shell decided to invest down-stream where the sensitivity to increases in crude oil prices was lower.

If the aim of scenario planning is to explore how to best adapt to and take advantage of what may come, the aim of backcasting is rather to find ways of shaping the future in accordance with visionary goals. By visualising possible solutions to the problem at stake and building on ideas outside the mainstream thinking of many influential actors, a backcasting study may broaden the conceptions of what is possible to attain. The results are not to be seen as cut-and-dried plans, but as an input to a process where the views of the future and available options are continuously being shaped and reshaped.

The targeted users are not the same
External scenarios are typically designed for and used by strategic planners of large- and medium-sized private enterprises such as Shell and Volvo. This is natural as the methodology was developed by a private corporation to meet its own needs. In this case the user is well-defined and often monolithic in character. What the user can control is also relatively clear. This makes the distinction between external and internal factors feasible to apply.

In backcasting the targeted users are typically a much broader and more heterogeneous set of people, although there are examples of studies carried out for a specific client. The targeted group may entail public sector planners at all levels, politicians, stakeholders of different kinds, grass-root movements as well as an interested general public. With such a broad set of addressees, the line between internal and external factors is much more difficult to draw.

The distinction between external and internal factors
Even though there is no clear line between external and internal factors in a backcasting context, there exist some truly external factors, e.g. the economic development and policy for trade in other countries or the emergence of new lifestyles and values. These have to be dealt with in backcasting in one way or the other. Usually this is done in step 3 (see above), analyses of paths to the Images. In this context necessary conditions (beside policy measures) for fulfilment of the targets are normally presented and discussed.

Höjer (2000, p. 14) argues that it is not necessary or even desirable to make the distinction between external and internal factors already in the phase where Images-of-the-future are developed. This is an innovative phase and to focus on what cannot be affected may hamper creativity. Another argument that Höjer (Ibid., p. 16) puts
forward is that the choice of external factors is partly normative. Of course, some factors are indeed external regardless of opinions, and these are the factors that cannot be influenced by the relevant actors (external factors in a strong sense). However, political views differ on what public policy should try to influence or control. Among factors that could be influenced, only a fraction are at any moment generally perceived as legitimate targets for political action. I use the term external factor in a weak sense when talking about factors that, although possible to impact, influential political groupings do not see as belonging to the domain of politics. Today some politicians are against road charging, basically because they do not think that politicians should interfere with citizens’ choice of transport mode. Other politicians have the opposite view. Consequently, road tolls are an external factor in the weak sense. Whether it is treated as internal – i.e. as a policy lever - or not depends on the actual political support for making use of it.

The view on road charging may change among some hesitant politicians if futures studies show that it can have a decisive role in a real solution to the environmental problems caused by road traffic and reconcile economic and environmental goals. Thus, a backcasting study could in some cases affect opinions on the factors that should be seen as internal policy levers. This is an important effect of backcasting studies. It can be seen as a merit of the methodology but it also involves the potential of political effects. This raises the issue of objectivity and the role and responsibility of science and scientists.

Scenarios, power and responsibility
Research intended to guide decision-making or to influence the perceptions of policy makers and the general public makes the researcher an actor of the political game where the society of tomorrow is being shaped. To some extent this also holds for traditional research, because new knowledge in the long run tends to have an impact on society’s development. However, the influence is much more indirect in this case.

What has been said about the researcher as an actor holds for the backcaster, scenario designer and developer of predictive models alike. This is an inevitable consequence if one wants to provide new knowledge that is relevant to decisions in societal planning. Although decision-relevant research is potentially rewarding to society, not all actors of the game will welcome the results of any given study, because the findings may speak against their interests.

There is, however, a difference between approaches that explore new paths for society and those that examine options within a business-as-usual framework. In a business-as-usual context the policy makers can usually easily follow the analysis of policy options supplied by the researcher and they are therefore less prone to be manipulated. When, on the other hand the researcher provides Images-of-the-future that imply new directions for action or external scenarios beyond common wisdom, the researcher is the one who sets the agenda and defines the issues. From a democratic point of view this may be worrying, because of a strengthened expert influence. Still, in a situation where the business-as-usual development entails serious
risks for society in the long run, and when these risks are not generally recognised or analysed, then studies of the backcasting kind should be welcomed. Of course the results and recommendations must be presented in such a way that assumptions are possible to scrutinise and criticise. A backcasting study should also contain a discussion on the effects on different parties of the proposed change of direction.

**Challenges for scenario approaches**
I close the comparative discussion by examining a few challenges to the two respective scenario approaches. I also try to identify their respective strengths.

**External scenarios for strategy development**
The strength of this methodology is that it helps customers (usually a private enterprise) to develop a more flexible and adaptive policy. The external scenarios will broaden their perceptions of possible developments of the firm’s environment and to be more receptive of early signs of change. The methodology has sometimes proven useful, as testified by van der Heijden (1996 pp. 18-19). Another strength is the participative character of the scenario design process, which involves relevant stakeholders and elicits their expert knowledge and judgement. This guarantees the relevance of the results and also increases their quality and acceptability.

The participative approach also entails challenges. The workshop methodology is demanding. Normally, it takes more than one workshop (and a lot of back-office work) to develop a set of scenarios. A participant usually also needs to prepare for the workshop by reading background papers. Furthermore, scenarios grow obsolete over time so there is a need for updates. All this may result in organisations becoming *scenario weary*. The best way to avoid this is probably to show that the scenarios have contributed to a better strategy for the firm. If this is not the case, one should consider whether scenario planning is really the best choice for the firm. It could be that the environment of the enterprise seems fairly stable even over the long term, or that the firm is capable of adapting swiftly to changing conditions. Alternatively the scenario generation process needs to be improved.

Another challenge is to hit the balance between innovative scenarios and acceptability. It sometimes takes an effort to persuade some workshop participants to think in terms of eventualities instead of predictions. Yet, this shift of perspective is necessary or no innovative scenarios will result.

Eriksson (forthcoming) points out that in some cases planning entities have to make decisions that are binding for many years and none of the options seem to be good in all scenarios. This is sometimes the case in defence planning and other investment-intensive branches, where the organisation has to be committed to a structure (e.g. a defence structure or a chemical plant). In such cases the criterion of challenging scenarios that span the uncertainty space may seem less relevant. However, Eriksson argues that the trend towards modular systems architecture makes adaptation to changes in the environment easier. Besides, it is almost always possible to find measures that at least marginally increase the ability to adapt to a wide range of
situations. One example is the creation of a trading unit at Shell, with the task of operating on the spot market in cases of price fluctuations. The bottom line is that although the need to commit an organisation to long-term real investments implies a challenge to scenario planning, it may still be useful.

When used by loose networks of actors of different kinds (this is often the case in public sector planning), it is sometimes difficult to define the external world – and the space of options. The relevance criterion for external scenarios points in different directions for different actors of the network. This means there may be a need for several scenario sets for different subgroups. Based on a common set of general scenarios, the scenarios targeted for a sub-group then focus on a specific area where the resolution is higher.

Backcasting
The strength of this approach is that it may provide new ideas on how a societal problem could be handled. Its main advantage lies in its impact on how we think about the future, especially as regards our ability to achieve real change in the long run when faced with a significant (societal) problem. The usefulness for guiding actual planning of a specific client has been less explored.

A challenge is how to avoid wishful thinking. In a sense, wishful thinking is the point of backcasting. After all, the Images-of-the-future should be desirable or at least intriguing. Still, it is very important that they are perceived as consistent and plausible and they should therefore be validated, preferably by external experts. Consistency, goal attainment and acceptability should be evaluated. The path analysis must be serious about what it takes to get there, and this does not just pertain to policy measures but to other necessary conditions.

Often, backcasting studies take a too limited approach to the dynamics of society’s development. According to Robinson (1990), the backcasting methodology involves “...working backwards from a particular desirable future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point.” This could be interpreted as a rather mechanistic view of development. In addition, there is really no reason why one must start from the Image-of-the-future and work backwards when exploring the path. It may be a better idea to try both ways, i.e. working from the present state into the future and from the end-point backwards to the present state. By iterating in this way the chances of finding a credible path increase.

There is a risk that presentations of paths leading from today up to an Image-of-the-future are taken as a suggested plan. Backcasting has often been criticised for implicitly assuming a planned economy. Of course, this need not be so. Instead the paths

---

30 Recent examples are two scenario studies led by the Swedish Defence Research Agency (FOI) for the Swedish railway system and the Swedish Technology Foresight exercise involving broad participation from the innovation system of Sweden.

31 (Robinson 1990)
together with the related Image should be seen as examples of developments that would be in line with the goals set up. Preferably, there should be more than one such example. Such examples could highlight a set of strategic issues to be encountered if the goals are to be attained.

The potential of backcasting for guiding actual planning is worth exploring. A recent field of application is to use backcasting in connection with Strategic Environmental Assessment (SEA) in an effort to integrate visionary environmental goals into planning processes (Noble 2000).

3.4 Summary
This chapter identified three modes of thinking about the future and discussed methodological approaches related to these modes. The main focus has been on predictive modelling (the predictive mode of thinking), scenario planning (the eventualities mode of thinking) and backcasting (the visionary mode of thinking), although other methodologies have been briefly discussed.

I have argued that the kind of uncertainty and the degree of interest in radical change should strongly influence the choice of futures study approach(es) and mode(s) of thinking. Predictive modelling is developed for the case where the dynamics of the relevant system are well understood, and uncertainty is confined to the future values of some external variables. In the presence of structural uncertainty, several different scenarios are often useful as a basis for discussing strategies. If present trends are seen as highly problematic, there is sometimes an interest in visionary goals and structural change. Then backcasting can be a useful tool.

Often, futures studies apply one of the modes of thinking and related methodologies. Sometimes, however, a broader perspective is needed. Some phenomena may be possible to predict with reasonable accuracy, while others are characterised by structural uncertainty. There may also be an interest in visionary goals and radical change, but there is a simultaneous need to keep track of strong external factors. This is why combined methodologies were tested in the studies presented in Papers 3 and 4.
III. Reflections on Papers 1-4

4. Paper 1: Learning by Gaming

Paper 1, Learning by Gaming, is a summary of a report in Swedish (Dreborg 1993) from a project (METSPÖ) on methodologies for gaming, carried out at FOI 1989 – 1992. It was a competence building project with the aim of increasing the ability of FOA to assist and give advice to clients in their use of gaming, especially in the field of planning for civil emergency preparedness.

In a long term programme for Swedish civil emergency planning (ÖCB, 1986) gaming and game-like exercises are identified as an important tool for the development of crisis management skills. It was also thought that gaming could increase the mental preparedness for crises. Essentially, gaming was seen as a complementary planning tool for coping with uncertainty.

The FOI project was launched because a theoretical framework for these kinds of applications was largely lacking. Such a framework was expected to facilitate an accurate analysis of the relationship between purpose, design and validity of games in this field. Below, some comments are made on Paper 1, especially relating it to the key concepts discussed in Chapters 2-3.

Learning games and explorative games

As indicated in Section 1.5, in game-like situations uncertainty related to intentions usually prevails. In repeated everyday games, such as positioning on an oligopoly market, agents learn how to act and the level of uncertainty is often kept relatively low. However, there are also game-like situations that appear rarely, such as various kinds of crises or conflicts, including war. In such cases the planning body may need to practise conflict management in a simulation game. There may also be a need to explore the options open to a specific agent (e.g. a city council or the national defence) in game-like situations using gaming. Both uses of gaming were treated in Paper 1. In the first case learning games were used with the aim of developing the players’ ability to cope with the game-like situation. In the latter case explorative games were used. Here the designer or conductor of the game is the one to learn. The aim was to increase the planning staff’s understanding of a class of threats or crises, and to test various strategies and tactics.

Learning games and uncertainty

Learning games provide planners with an experience of several extraordinary situations that might happen and this probably increases their ability to also act adequately in situations not simulated or foreseen. In chess, a game is never repeated in all details and new situations can always arise. It is well known that experience from a limited number of games increase the player’s ability to rightly assess and
cope with previously unmet situations. If one loses to a more experienced player, the loss does not depend on the more experienced player having met exactly the same positions before, but his greater experience may still be the decisive factor.

Normally, we learn how to manage situations by getting practice e.g. through job training. However, in preparing for rarely occurring emergency situations, we do not get natural training in our everyday life. Therefore, there is a need to set up an artificial framework for planners to gain experience. Here, gaming may work as a substitute for reality, and may give the participants at least some experience of e.g. crisis management. Part of the artificial framework is scenarios describing the threat or challenge that the players of the game must handle. In order to enhance the crisis management ability of the players, as is the aim, several different scenarios should be used, if not on every gaming occasion at least over some period of time. The reason, of course, is the same as in scenario planning à la Shell (the eventualities mode of thinking): One needs a broad perception of what may happen in order not to be taken by surprise. Gaming increases the ability of players to handle a few different types of emergency situations (specified uncertainty), and probably also has some positive effect on the ability to cope with true surprise (unspecified uncertainty).

**Explorative games and uncertainty**

Two pure forms of explorative games (as well as learning games) are the context-rich game and the simple and idealised game. The context-rich game can be used much like a case study, while the simple and idealised game can be used as a controlled experiment. The context-rich game is useful when one wants to explore a complex problem area that is not well understood. In the terminology of Section 1.2 it can be said that there is a considerable and unspecified uncertainty as regards the dynamics of the studied system. Explorative gaming is then used in order to get a better understanding and to help specify and structure the uncertainty.

The simple and idealised game requires a relatively well specified and structured problem area. A few variables or relationships are varied, while other factors are kept constant. One may e.g. test a military defence strategy against several antagonistic strategies. In such cases the uncertainty is rather well specified and the gaming procedures can help to partly resolve uncertainty.

**Gaming and tacit knowledge**

A hypothesis of Paper 1 is that there is a connection between tacit knowledge, implicit learning and gaming. Learning games may be a vehicle for acquiring tacit knowledge of how to cope with a certain kind of situation, e.g. a crisis.

Furthermore, a special variety of explorative games work the other way round by helping the planner/researcher to decode the players’ tacit knowledge, thereby

---

32 Tacit knowledge is knowledge that is difficult or even impossible to communicate verbally. The term was introduced by Polanyi (1957). Tacit knowledge is essentially about ways of doing things, when the focus of attention is on the task or goal. Reber uses the term implicit learning for the learning process where tacit knowledge is acquired (Reber and Lewis 1977; Reber 1989).
making it partly explicit. In the expert game people with tacit expert knowledge are confronted with different tasks and have to make (or propose) decisions. Their choices are based on their expert knowledge, which is elicited by letting them motivate and reflect upon their decisions. It is the concrete setting of the game that makes it easier to spell out the hitherto tacit knowledge. Here, the game is a planning tool for investigating various strategies.

To sum up, gaming can contribute to uncertainty management by
   a) improving the ability of key actors to act adequately in game-like situations that are preconceived as possibilities, but not experienced so far (learning games);
   b) to some extent improving the ability of key actors to cope with situations entailing true surprise (learning games);
   c) highlighting threats, possibilities and options in game-like situations (explorative games);
   d) partly resolving and/or structuring uncertainty related to future possible threats and crises (explorative games).

The project has had an impact on game design in several cases in civil emergency planning. The Swedish report is still used in internal training programmes at FOI.

---

33 The term ‘expert game’ was introduced by Moynihan (1987).
5. Paper 2: Essence of Backcasting

Paper 2, Essence of Backcasting, is based on experiences of projects on sustainable transport and previous studies on energy systems at FOI, but also on a reading of literature on methodology and theory of science.

The aim was to identify the niche for backcasting by describing conditions that speak for this approach. A perspective including epistemological assumptions behind backcasting is outlined and contrasted to that behind “traditional forecasting”. In the terminology of Sections 1.2 and 2.2 above, this signifies predictive modelling (forecasting in a narrow sense) and the predictive mode of thinking. However, the kind of uncertainty involved is at the centre of the discussion, as it is in the other papers of this study.

A main line of argument in Essence of Backcasting runs (in condensed form) as follows: In the long run there is a large scope for Man to influence the development of society by decisions and actions. Furthermore, decisions to a large extent depend on the intentions of the actors involved, and those intentions are influenced by desires and beliefs, which in turn are affected by new knowledge. If we believe in the growth of knowledge, we must admit that the content of future knowledge cannot be predicted. Thus, the long-term development of society is always underdetermined from the point of view of present knowledge. This I shall call the argument of indeterminacy of the future. As can be seen, there is a special focus on uncertainty of intentions.

In the terminology of Section 1.2 above, this is an argument for the presence of structural and/or unspecified uncertainty. In social systems people learn from the development and adapt their behaviour. Thus, there is a feedback link from the performance of the system to the behaviour of the actors. However these will also, as a result of their new insights, change the system, which is a feedback link in the other direction. Therefore, social systems tend to develop according to a non-linear dynamic, making them difficult to predict over the long-term. This, as I have argued above, speaks for a scenario approach. The choice of backcasting as the main scenario approach has to do with the interest in visionary goals.

Another argument in Paper 2 is that in the long run the development of society is affected by many actors, not just by a well-defined group of decision-makers. Because people’s perceptions of future possibilities have an impact on their choices, it is a meaningful task for futures studies to provide a broad group of interested people with a material that highlights images of the future and how these can be realised. This is the argument of the many actors.

---

34 The argument about the impossibility of foreseeing the content of future knowledge has been put forward by Popper (1961, p. vi of the Preface), and Ken Boulding (Boulding and Boulding 1955, p. 15).
Both these arguments underpin the conclusion that futures studies of the long-term development of society should have the aim of widening perceptions of what futures are attainable. The uncertainty argument also leads to the conclusion that an adaptive approach to planning and change should be supported. New knowledge will lead to revisions of plans and sometimes of goals as well. Therefore, results from a futures study should not be viewed as a fixed action plan, but rather as an input to an ongoing process.

Several years have passed since this paper was written and I have gained experience from many other futures orientated studies in the field of sustainable development. The STEEDS project, treated in Paper 3, combined a predictive modelling approach with explorative external scenarios, while the POSSUM project, presented in Paper 4, developed a methodology based on explorative, external scenarios and backcasting. These and other experiences have influenced my view on futures study methodologies and approaches. Some comments on Essence of Backcasting from my present point of view are, therefore, called for.

I still find the rationale of backcasting, briefly described above, convincing. However, the account given of some other approaches seems a bit too limited. Furthermore, today I would emphasise the usefulness of mixed methodologies more.

It seems to me that too little attention is given to other scenario approaches, especially of the explorative kind. These may be equally well suited to inspiring new ideas and to broadening the conceptions of the future. Some of the arguments put forward in favour of backcasting are actually arguments for scenario approaches generally. This evidently holds for the indeterminacy argument, which essentially points at the presence of structural or unspecified uncertainty. In addition, the many actors argument may speak for studies that can widen people’s perceptions of possible developments in general, not just desirable future states (Images-of-the-future). Hence, a mixed methodology that combines external scenarios with backcasting, as in the POSSUM project, may be a good choice.

Furthermore, the attitude taken towards predictive modelling in the case of structural uncertainty seems slightly too negative. I still would not recommend it as the sole methodology of a futures study in such cases, especially not if used to find the most likely development. The general perspective must be much broader in cases where structural uncertainty is present. However, more explorative ways of using models can be found, e.g. to analyse various hypothetical new dynamics of the system of interest. If combined with qualitative and structurally different scenarios, models can be used to analyse the scenarios in depth. They may also help to make the scenarios internally consistent. This example also demonstrates that mixed methodologies are sometimes of interest.

One argument used in Paper 2 against mathematical models of social systems is that people’s choices are treated as predetermined according to some persistent behavioural pattern, and that this seems problematic in long-range studies in view of
the indeterminacy argument. Now I am inclined to think that this need not be that problematic. Models could e.g. be used to test the consequences of different behavioural assumptions. Furthermore, if used as an input to a dialogue with different parties and in combination with a discussion about intentions and goals, such modelling work can be useful.

To sum up, Paper 2 gives the important arguments for backcasting and identifies its niche, which was actually the aim. However, the indeterminacy argument and the many actors argument also speak for explorative external scenarios (scenario planning and similar approaches). Furthermore, sometimes mixed methodologies could be of interest. The niches of backcasting, explorative external scenario approaches and quantitative modelling approaches are not mutually exclusive. Instead, they seem to partly overlap.
6. Paper 3: The STEEDS decision tool

STEEDS was a project within EU’s 4th framework programme. It started in 1996 and went on for 3 years. It developed a decision support tool for policy analysts at the European and national levels. The main purposes of the tool are according to Dreborg, Eriksson and Wouters (1997):

- to project the market uptake of different transport technologies under various scenarios and policy options;
- to assess the energy, environmental and other impacts of these different technology mixes.

The architecture of the modelling system (see Figure 3) is similar to the planning model of Figure 1 in Section 2.2. It would be a perfect case of predictive modelling (forecasting), were it not for the way external variables were generated and linked to the model. Instead of just defining a set of external variables and feeding their values into the model, in STEEDS these variables stem from external scenarios developed according to the scenario planning tradition of Shell and GBN.\textsuperscript{35} The basic idea of using scenarios of this kind in STEEDS was to provide a wider context and uncertainty analysis for the development of the studied transport system. The scenarios are structurally different.

If the linking of scenarios to the modelling system had been just an input vector of variable values, then the approach would have been a conventional model-based forecasting methodology. Uncertainty related to variations in input data could then be analysed, but the structure of the model would be unaffected. What makes STEEDS a combined approach is that structural aspects of society, such as settlement patterns, spatial organisation of production, lifestyle, dematerialization of production and organisation of transport markets have an impact on a few strongly scenario dependent variables, viz. transport intensity (for passengers and freight respectively), passenger transport split and split of demand on journey segments. Values for these variables are not just input data, but have an impact on the modelling system by adjusting its default way of working. Thus, passenger transport intensity varies between scenarios due to differences in values, land use etc. Consequently, income elasticity of demand for transport differs depending on scenarios. Technically, this is achieved by using a transport intensity index as a multiplier in the models.\textsuperscript{36} Therefore one could say that the transport demand model differs structurally between scenarios. In one of the scenarios, where green values are widespread, residential patterns are denser than today etc., this reduces transport intensity (per unit of GDP) by 20\% by 2030. In another scenario, transport intensity increases by 15\%.

\textsuperscript{35} This author was responsible for the workpackage that worked out the scenarios and designed the linking of scenarios to the modelling system. Paper 3a presents the scenario methodology and the resulting scenarios. In Paper 3b the interface between scenarios and the modelling system is presented.

\textsuperscript{36} See Paper 3b.
I have previously noted that the distinction between external and internal is not the same in scenario planning as in a modelling approach (cf. Sections 2.2 and 4.1). This may now be illustrated. When elasticity of transport demand is changed between scenarios, this is seen as a change of an internal factor in predictive modelling, because the model itself is changed. However, from the scenario planning perspective it is a change of an external factor, because elasticity of demand is beyond the control of the planning entity.

Figure 3: Architecture of the STEEDS modelling system.

The strongly scenario dependent variables reflect the structural differences between scenarios and are, hence, a means to explore structural uncertainty. They make the modelling system mirror the structural differences between scenarios. These variable values should not be changed by the user/policy analyst, since that would require a new set of scenarios. The set of scenarios delivered as a part of the STEEDS tool is designed to cover the credible range of structural uncertainty.

Besides the strongly scenario dependent variables, there is a set of more conventional external variables that do not interfere with the functional relationships of the models. These variables are divided into two categories: moderately scenario dependent and weakly scenario dependent. An example of a moderately scenario dependent variable is the growth rate of GDP. This could be varied by the user, but the order between scenarios as regards growth rate should be retained. The number of households and car price indices are examples of weakly scenario dependent variables. These could be varied freely by the user, and there is no need to correlate the variations between scenarios.

The moderately and weakly scenario dependent variables lend themselves to ordinary sensitivity analysis, which is a way of analysing quantitative, non-structural uncertainty. Thus by combining external scenarios with predictive modelling, the
STEEDS approach can cope with both structural uncertainty and quantitative uncertainty.

Although STEEDS is a mix between predictive modelling and scenario planning, it is possible to go further in this direction. In STEEDS the models are adjusted to some extent depending on scenario. A more radical step would be to design different models for each scenario. Then it would be possible to have different sets of internal as well as external variables. The point would be to better cover the differences between scenarios. However, such a study would require larger resources. Besides, if users of the tool feel there is a need to update the scenarios, this would be a formidable task, since the models would have to be changed as well. With the actual architecture of the tool, only minor adjustments would be needed.

There seems to be a trade-off between precision and scope when one explores the future. On the one end of the scale there are the predictive models that accurately analyse several cases that are structurally similar. On the other end there are the external scenario exercises that cover a few structurally different futures but mainly qualitatively. The STEEDS approach is designed to allow many cases, clustering around a few standard scenarios, to be analysed in detail. The standard scenarios are structurally different and the modelling system can partly reflect these differences. However, if many variations are made of each standard scenario, the overview is soon lost. So, the user should primarily cover the four standard cases but with some variations of each. If just one scenario is picked, the point in having scenarios is lost and the system reduces to pure predictive modelling.

The trade-off argument casts some doubt on an approach where different models are designed for each scenario in a set of scenarios. If there is a need to cover a large scope of structurally different futures then the qualitative differences are probably the most interesting. Would it be worth the effort to make precise model-based calculations of several variations of these scenarios?

It is also questionable whether the STEEDS tool has the appropriate design for the very long time frame chosen (30 years). In that time perspective the structural differences between the scenarios might well be the most interesting. Perhaps the niche for the STEEDS methodology is medium-range studies (around 15 years).

The STEEDS project was carried out according to the think-tank model, although the think-tank was a consortium created specifically for the task of performing the project. Panels of experts were used on several occasions for the development of external scenarios. This was done in accordance with the inductive variant of the Shell/GBN methodology. The decision support tool developed in the project was intended for consultancy work, to be carried out by partners of the consortium for transport policy planning bodies at the European and national levels, and to some extent business companies. It has been used in this way by some partners.
7. Paper 4: The POSSUM study - policy scenarios for sustainable mobility

POSSUM, like STEEDS, was a project within EU’s 4th framework programme. The main task was “…to construct scenarios for achieving the objectives of sustainable mobility and to assist in future decision-making about the Common Transport Policy and the development of the Trans-European Networks.” (Banister et al. 2000, p. 111). It is obvious that the task entails using some kind of backcasting approach, since the scenarios should all meet the requirements of sustainable mobility. However, the actual methodology chosen integrated the backcasting approach with an element of external scenarios. The main reason for testing a mixed methodology was that the POSSUM scenarios were meant to inform actual policy development at the European Commission and by national policy analysts in different countries. Then, it was assumed, it would help to have a comprehensive view of the field of driving forces and influential pervasive phenomena in society because these will affect the choice of strategies (see Figure 4 below).

![Diagram showing the components of the POSSUM Images-of-the-future.](image)

**Figure 4. Components of the POSSUM Images-of-the-future.**

The alternative would be to analyse the role of external conditions for reaching the Images of sustainable mobility, but not to build such external factors into the very Images. The methodology chosen pays more attention to non-policy factors. If the aim of the POSSUM project had been to stimulate a public debate about sustainability and change, then the usual backcasting approach would have been reaso-
nable. Even in this case external factors must be analysed and the scenarios need to be validated, but these issues would not have been brought into the limelight.

The bottom line is that the closer to actual decisions the research lies, the more attention should be paid to factors influencing the decision but lying beyond the control of decision makers. In actual planning under uncertainty, consideration of such external developments is as important as the planning targets.

The key step in forming the Images was to match the ovals according to Figure 4 to each other. This was done by first choosing the contextual framework (ovals 1 and 2 in Figure 4) – or external scenario components – and then adapting the policy (oval 3) to the context in such a way that the transport system (box 4) met the sustainability targets (box 5).

It was assumed already from the beginning that sustainability was possible only if there was a sufficient interest in environmental and sustainability issues in society. Development could be driven either by grass-root movements or by political leaders. In an external scenario with dominant economistic values and a lack of ability to cope with environmental problems, sustainability targets will not be attained. Therefore, the scenarios of POSSUM do not span the space of possible futures, but only a subset of futures that are judged to be compatible with sustainability. This may seem to be an important difference to external scenario planning. However, it is not the focusing on a subset per se that is the difference. Even in scenario planning it is just possible futures of relevance to the planning issue that are considered. However, in POSSUM the relevance criterion leads to a normatively defined subset, whereas in scenario planning the subset of relevance is defined in a non-normative way.

Given the subset of possible and relevant developments, in POSSUM the structural uncertainty has been addressed in a systematic way.

The two main strategies used in the policy scenarios are development of more efficient and cleaner technology and decoupling of transport volume development from GDP development. The relative importance of technology and decoupling varies between scenarios, depending on factors such as values, lifestyles, the attitude to environmental problems and the kind of global governance. The general approach to quantification of the scenarios was as follows. First, technological improvements in terms of emissions reductions from transport were assessed, taking the framing conditions of each scenario into account. This meant e.g. that in the top-down scenario with responsible leadership, the conditions for global environmental standards would be better than in the bottom-up scenario, which lacked the international accord on environmental issues. Therefore, the technological improvements are more pronounced in the top-down scenario. Next, the levels of decoupling needed to reach the emissions targets were calculated, given the contribution to goal fulfilment of cleaner technologies. Thus, the level of decoupling compared to a business as usual

37 The contribution of this author to the POSSUM project consisted of the overall scenario methodology and the architecture of the set of scenarios. This is treated in Part 2 of Banister et al. (2000), which is included in this thesis as Paper 4.
development was a residual. Afterwards, the calculated levels were compared to assessments of the potential decoupling effect of various policy measures (Banister et al. 1997; Schleicher-Tappeser and Hey 1998). The calculated values were regarded as a challenge to politics, but not impossible to achieve. However, the uncertainty of the potential of decoupling policies must be stressed.

The mixed approach could be developed further. One could relax the criterion that all external scenarios should admit the fulfilment of targets (e.g. of sustainability). Instead it would be sufficient that they be relevant to the policy interest in sustainability. This would result in a wider class of external scenarios being taken into account. For each external scenario chosen the following questions would then be addressed: In this scenario, is it possible to attain the targets (e.g. sustainable transport)? If so, how could it be done? This is the backcasting element of the mixed methodology. With an approach like this, a possible outcome could be that in some scenarios the targets will not be met. Then one can examine how far it seems possible to proceed towards the target.

Such a development of the mixed methodology would give equal weight to both the external and the backcasting components and the point would be that it could lead to a better understanding of the limiting conditions for target fulfilment. On the other hand it would require more resources, in terms of person-hours, than were available for the POSSUM project.

POSSUM was intended for public sector planning entities at the EU and national levels, mainly the Commission and governmental agencies. The aim was inspirational rather than to guide actual planning in a more specific way. The study was carried out in accordance with the think-tank model, with the think-tank being the ad hoc consortium responsible for the project. The results were well received by the Commission and there were indications that they would influence research tasks of the fifth framework programme. However, it turned out that no clear follow-up activities were to be found in the following calls for proposals. The impact of projects with an inspirational aim and a think-tank way of working is difficult to evaluate.

For studies like POSSUM to have a real impact on the policy forming of e.g. the European Commission, it is probably necessary to apply a participative process that involves the client organisation in scenario development and analysis of policy paths. However, experiences from another EU-funded project indicate that the Commission may be reluctant to commit itself to an open, explorative process, such as scenario planning or visionary planning based on backcasting (Dreborg and Eriksson 1999). This was a project in which the Commission clearly was the client and problem owner. The unwillingness to take a more active part in the project may reflect a policy of non-intervention in ongoing research, based on the idea of a linear model of R&D (first research, then implementation). To engage a consultant to facilitate the process might be easier.
Furthermore, public sector entities may find it difficult to engage in scenario based strategy development in cases where the issue at stake is politically controversial. In such cases political parties tend to commit themselves to a special course of action, or to rule out some options for ideological reasons. Then it seems to be problematic to take active part in scenario based planning, where the idea is to explore and assess a broad variety of policies with an open mind.
IV. Concluding remarks

I conclude this thesis by summing up conditions for application of the planning tools considered above. These were predictive modelling, two pure forms of scenario approaches, namely external scenarios (scenario planning of the Shell/GBN type) and backcasting, the mixed forms predictive modelling – external scenarios and external scenarios – backcasting, and finally gaming.

The choice between a predictive modelling approach and the scenario approaches should essentially be based on the dominant kind of uncertainty. If the uncertainty is mainly quantitative, then a model-based methodology could often be employed. If, on the other hand, the uncertainty is mainly structural, scenarios and sometimes gaming are better tools for guiding policy making and learning.

The choice between an external scenario approach and backcasting is dependent on whether or not there is an interest in trend breaks and visionary goals. Visionary goals speak for backcasting, while scenario planning is the better choice when the goals are of a pragmatic and opportunity seeking nature. Examples of visionary goals are sustainable transport and an energy supply system based on renewable sources. An example of a pragmatic goal is for a firm to keep or increase its market share despite structural uncertainty as regards the external development.

There are other factors that have a role for the choice between backcasting and scenario planning. The visionary goals of backcasting normally require that the targeted user of the study is able to induce profound (structural) change, e.g. breaking the trend of increasing passenger transport by private cars (societal planning) or establishing a firm on a new market (planning in business enterprises). Thus, the relevant actor (actors) must have a considerable potential influence on the relevant system at large, or backcasting will be of little interest.

The choice of a visionary goal and an ability to induce real change does not imply that the implementation of a chosen strategy follows a predefined plan. Instead, the policy for change should be adaptive to new information and unforeseen events. Even the goals may change in a learning process.

A large influence at the systems level may often, though not always, require the support of broad groups of actors. In societal planning a change of direction, e.g. regarding mobility patterns, must be supported or at least accepted by large groups of citizens. Therefore backcasting studies in such cases usually address stakeholder groups and an interested general public besides policy makers at different levels, in an effort to open up new ways of thinking about the future. Therefore, such studies are not as close to actual decision-making as scenario planning usually is.

The different conditions for the two pure forms of scenario methodologies are summarised in Table 2.
Table 2. Conditions for scenario planning and backcasting in the typical case

<table>
<thead>
<tr>
<th></th>
<th>Scenario planning</th>
<th>Backcasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targeted user</td>
<td>Policy makers</td>
<td>Policy makers, interest groups, general public, and academia</td>
</tr>
<tr>
<td>Aim of study</td>
<td>Guide strategic policy making (close to actual decision-making)</td>
<td>Stimulate debate and new ways of thinking (not so close to actual decision-making)</td>
</tr>
<tr>
<td>Goals of interest to targeted user</td>
<td>Pragmatic (opportunity seeking)</td>
<td>Visionary (involving structural change)</td>
</tr>
<tr>
<td>Influence on system at large of targeted user</td>
<td>Limited</td>
<td>Large</td>
</tr>
</tbody>
</table>

As shown in Papers 3 and 4, combined methodologies are sometimes used. In the STEEDS case, a combination of predictive modelling and external scenarios was employed. The main intended users were policy makers at the European Commission and at the national level, and the aim was to inform policy making. Both quantitative uncertainty and structural uncertainty were judged to be of interest. This was the main reason for trying a mix of predictive modelling and external scenarios, which admitted sensitivity testing of several external variables as well as exploration of robustness of policy measures across a set of structurally different external scenarios.

In the case of POSSUM, the task entailed working with backcasting and visionary goals of sustainable transport. However the aim was to inform policy making at the European Commission and national level planning bodies, so the work was closer to decision-making than many other backcasting projects, although not as close as scenario planning à la Shell/GBN. Therefore, it was felt that factors external to the transport sector, but salient to its development, ought to be treated in a transparent and systematic way.

In Table 3, conditions prevailing in the cases of the mixed methodologies of STEEDS and POSSUM are summarised.
Table 3: Important conditions for the mixed methodologies of STEEDS and POSSUM

<table>
<thead>
<tr>
<th>Methodology</th>
<th>STEEDS</th>
<th>POSSUM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mix of predictive modelling &amp; external scenarios</td>
<td>Mix of external scenarios and backcasting</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Quantitative and structural</td>
<td>Structural</td>
</tr>
<tr>
<td>Targeted user</td>
<td>Policy analysts</td>
<td>Policy analysts</td>
</tr>
<tr>
<td>Aim of study</td>
<td>Inform policy making</td>
<td>Inform policy making</td>
</tr>
<tr>
<td>Goals of interest to targeted user</td>
<td>Pragmatic</td>
<td>Visionary</td>
</tr>
<tr>
<td>Influence on system at large of targeted user</td>
<td>Limited</td>
<td>Relatively large</td>
</tr>
</tbody>
</table>

The two last rows on goals and influence respectively, are worthy of comment. In both cases (STEEDS and POSSUM) the European Commission is the main targeted user. The issues are similar. The environmental and climate effects of transport and measures to counter them are at the heart of both projects, but STEEDS is more technology orientated. However, as to the goals the approaches differ greatly. In the STEEDS case, the focus is on policy measures and what can be attained by various combinations of them. This implies a pragmatic view of goals. In the POSSUM case the starting point is the visionary goals of sustainable mobility. Policy packages are then sought that would lead to goal fulfilment within the time horizon chosen. Implicitly, in STEEDS the influence on the transport system at large of the planning entity is assumed to be relatively limited. That explains the attitude taken to goals. In POSSUM a relatively large degree of influence is implicitly assumed, that goes with the visionary goals. This may seem strange as the targeted user, the issue and the time horizons are similar. Yet, it may be a sound strategy of the Commission to support both approaches. As discussed in Section 4.3, the distinction between external (non-influential) and internal (influential) is not clear cut. Between factors that are impossible to affect and those that most agree are possible to affect, there are factors that some think should be regarded as external, while others see the same factors as internal. This has to do with values, and these may vary over time. In short, there are different views on what the EU (including the Commission) legitimately could try to influence as regards the European transport system. Then it seems reasonable to investigate both a more limited political commitment and a more far-reaching one, in order to identify the advantages and disadvantages of both.

In Part II, a distinction was made between three basic modes of thinking about the future – the predictive mode, the eventualities mode and the visionary mode. Table 4 shows the mode of thinking that is typical for the planning tools discussed in this study. Different kinds of uncertainty - quantitative, structural and unspecified – were also identified because these were assumed to require different approaches to planning.

52
tools. Table 5 indicates the kind of contribution to uncertainty management made by the planning tools of this study.

<table>
<thead>
<tr>
<th>Planning tool</th>
<th>Modes of thinking</th>
<th>I. Predictive mode</th>
<th>II. Eventualities mode</th>
<th>III. Visionary mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Predictive modelling</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. External scenarios</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3. Gaming</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(Paper 1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Backcasting</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(Paper 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Mix of predictive modelling &amp; external scenarios</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(Paper 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mix of external scenarios and backcasting</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(Paper 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning tool</td>
<td>I. Quantitative uncertainty</td>
<td>II. Structural uncertainty</td>
<td>III. Unspecified uncertainty</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>-----------------------------</td>
<td></td>
</tr>
<tr>
<td>1. Predictive modelling</td>
<td>Policy analysis with sensitivity testing of external variable variations</td>
<td>Tool for development of robust and adaptive strategies</td>
<td>Improves mental preparedness for wider range of possibilities</td>
<td></td>
</tr>
<tr>
<td>2. External scenarios</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Gaming (Paper 1)</td>
<td>In cases of uncertainty related to intentions: Improves the ability to act adequately in game-like situations that are pre-conceived as possibilities but not experienced so far</td>
<td></td>
<td>Improves the ability of key actors to cope with novel situations</td>
<td></td>
</tr>
<tr>
<td>4. Backcasting (Paper 2)</td>
<td>Inspirational role Widens perceptions of what is possible to attain in the long run</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Mix of predictive modelling &amp; external scenarios (Paper 3)</td>
<td>Policy analysis with sensitivity testing of external variable variations</td>
<td>Policy analysis across structurally different external developments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mix of external scenarios and backcasting (Paper 4)</td>
<td></td>
<td></td>
<td>Explores how a policy for achieving far-reaching goals can be adapted to various external developments</td>
<td></td>
</tr>
</tbody>
</table>
References


Quist, J.N. Forthcoming. “Greening foresighting through backcasting: more than looking back from the future.” In Foresighting and Innovative Approaches to Sustainable Development, edited by Walter Wehrmeyer, Anthony Clayton, and Ken Lum.


