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WHAT IS THE POINT OF IT?

Backcasting Urban Transport and Land-Use Futures

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Abstract

Sustainable development, future studies, information technology, urban land-use and passenger transport. These are the five concepts upon which this thesis and the eight papers it contains are based. The thesis includes both a development of future studies methodology, especially with regard to backcasting, and analyses of the relationship between sustainable development, information technology, transport and land-use in future cities.

Paper I (Gudmundsson & Höjer, 1996) suggests four sustainable development principles and discusses the implications of these four principles for the transport system.

Paper II (Höjer & Mattsson, 2000) is a methodological paper where backcasting is discussed in relation to some other future studies approaches. Moreover, the use of a number of common empirical approaches in such studies is criticised for being too deterministic.

Paper III (Höjer, 1997) presents a study where four technical scenarios of intelligent transport systems were generated and evaluated. The evaluation used a Delphi-inspired backcasting approach, where a total of some 100 international experts contributed to a two-round survey.

Paper IV (Höjer, 1998a) highlights three of the scenarios generated in Paper III and elaborates some results from the evaluation of them.

Paper V (Steen et al., 1999) uses assumptions, based on other studies, regarding global future energy supply as well as on the development of vehicle technology and traffic volumes. Based on these, a scenario of a sustainable transport system for Sweden in 2040 is developed.

Paper VI (Höjer, 2000b) looks at how the patterns of commuting and land-use can change with new organisational forms. The change can either contribute to reduced traffic volumes and a more sustainable transport system, or it can lead society even further into unsustainability.

Paper VII (Höjer, 2000a) reports from a calculation of potential effects on commuting from a change towards a node-structured Stockholm region. The calculation is based on origin-destination matrices generated from a traffic analysis model.

Paper VIII (Höjer, 1996) is a generalising analytical paper on the relationship between information technology, especially transport telematics, and sustainable development.

CONTENTS

PREFACE

Thank you.

A major proportion of the readers of this thesis, at least those of you who are beginning your reading with this preface, most probably deserves thankfulness. Therefore, I thank you for your support, even if your name is not mentioned below.

A number of institutions have been helpful during my work. In the first years I had my office at Traffic and Transport Planning, where I also presented my Licentiate thesis. At that Department, there were many nice and friendly colleagues, but we had quite different research interests and approaches.

In 1994, I met with Peter Steen, by then director of the Environmental Strategies Research Group (ESRG). Peter offered me an office in the group's premises, and there I have stayed since. Peter's direct and unpretentious way of leading the daily work created an atmosphere of friendship and joy and his unconventional way of approaching scientific matters gave me courage and inspiration. For me, the meeting with Peter and the group became decisive for the direction of my work. Peter died very suddenly only a couple of days before this was written. I miss him a lot.

I have had good support from my supervisors at the Royal Institute of Technology: Lars-Göran Mattsson, Transport and Location Analysis and Folke Snickars, Regional Planning. The support from Folke stems from the time when I began studying for my doctorate. Thank you for your encouragement and belief which I have felt there all the time. You have kept me on the right track, even if my speed sometimes has been slow. My co-operation with Lars-Göran began about three years ago. I am full of admiration for your wide area of interests, your ability to mix social and scientific discussions, and to find constructive ways of developing preliminary ideas. I also wish to thank Folke and Lars-Göran for not only accepting, but also affirming, my approaches and my co-operation with ESRG.

A number of persons have been helpful with comments on the different parts of the thesis. Most of the papers included have their own acknowledgements, but I wish to send a special thank you to Henrik Gudmundsson for a good co-operation when we wrote our first scientific paper (Paper I in this thesis). Some of you have provided especially useful comments to the introductory part. Thank you Kalle Dreborg, Anders Gullberg, Greger Henriksson, Sven Hunhammar and Maria Wendt Höjer for very helpful comments. And Anders E Eriksson, discussant at the final seminar before this thesis was printed also deserves gratefulness for a good job and useful comments on the complete work.

Financial support for the first part of the thesis was provided by the Swedish Transport and Communications Research Board (KFB), where especially Christine Wallgren has been of great help. The second part of the thesis was supported by KFB together with the City of Stockholm, the Stockholm County Council and the Stockholm County Administrative Board. The support from the later three organisations was co-ordinated by the Network of traffic planners and researchers in Stockholm (Trafiknät Stockholm). Their support is gratefully acknowledged. Magnus Carle from the Office of Regional Planning and Urban Transportation, Stockholm County Council and Stig Holmstedt from Stockholm City Planning Administration have played especially important and active roles in a reference group during the last years of study.

The cover was designed by Norbert Roblès. Thank you again! Now I can only wish that the printed cover will look as good as the original painting does.

My family consisted of only my wife Mia, myself and our then new-born Kalle when my thesis work began. I am happy to have been able to share my time between the work with this thesis and being with Mia, Kalle, Fanny (born 1993) and Ella (born 2000). And I am quite convinced that finding a balance between family and work is one of the most important factors for well-being.

In fact, I have found empirical evidence of a unison development of thesis pages and length of children (see Figure P.1.1).

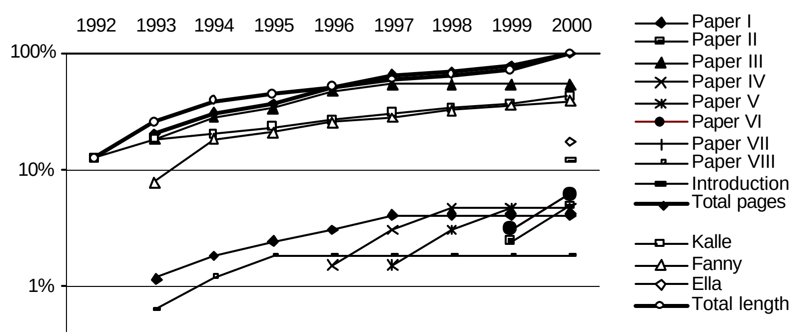

Figure P.1.1: Growth of thesis length and children length in my family measured in total page number and total length of children in centimetres in form of an index 2000=100 (Höjer, 2000c and own estimates).

The long-term parity rate appears to be in the vicinity of 1 thesis page per centimetre child. While the growth of thesis length and child length did not evolve completely in unison, they do enhance each other and show many parallel developments (see also Paper II).

Finally, I wish to thank my mother Christianne Eberstein, for all the time she has spent with Kalle and Fanny. This has made it easier for both me and Mia to keep on working with our respective theses. Evidently, this thesis would have been ready a long time ago if we had not had children or if we had spent less time with them. But the question must be – what is the point of it?

LIST OF PAPERS

Paper I	Gudmundsson, H. & Höjer, M. (1996). Sustainable development principles and their implications for transport. *Journal of Ecological Economics, 19*(3), 269-282.
Paper II	Höjer, M. & Mattsson, L.-G. (2000). Determinism and backcasting in future studies. *Futures, 32*(7), 613-634.
Paper III	Höjer, M. (1997). *Telematics in Urban Transport - a Delphi Study Using Scenarios.* TRITA-IP FR 97-23. Infrastructure and Planning, Royal Institute of Technology, Stockholm.
Paper IV	Höjer, M. (1998a). Transport telematics in urban systems - a backcasting Delphi study. *Transportation Research Part D, 3*(6), 445-463.
Paper V	Steen, P., Åkerman, J., Dreborg, K.-H., Henriksson, G., Höjer, M., Hunhammar, S., & Rignér, J. (1999). A sustainable transport system for Sweden in 2040. In H. Meersman, E. van de Voorde & W. Winkelmans (Eds.) *World Transport Research – Selected Proceedings from the 8th World Conference on Transport Research, Antwerp, Belgium, 12-17 July 1998.* Vol. 3. Pergamon, Amsterdam, p. 667-677.
Paper VI	Höjer, M. (2000b). Telecommunicators in the multinuclear city. In F. Snickars, B. Olerup & L.-O. Persson (Eds.) *Reshaping Regional Planning.* Ashgate, Aldershot, p. 347-362.
Paper VII	Höjer, M. (2000a). *A hundred nodes in the Stockholm region – a simple calculation of the effects on commuting, Revised version.* Paper presented at the 3rd KFB Research Conference, Stockholm, June 13-14, 2000.
Paper VIII	Höjer, M. (1996). Urban transport, information technology and sustainable development. *World Transport Policy and Practice, 2*(1-2), 46-51.

1. INTRODUCTION

In a world where environmental degradation is a major problem and possibly a critical issue for the long-term existence of our society, solutions ought to be sought from different points of departure and from various fields. It seems as if the pressure on the global ecosystem is increasing continuously.

It would be easy to say that the reason for this is the industrial society, primarily due to its extensive use of energy for production, transport and temperature regulation. However, the development of technology in the industrial society is also a factor that gives hope, or at least opportunities. From a certain perspective, the environmental problems can appear to be easily solved. Strong technology optimism, paired with an equally strong belief in a rational interplay between technology and the economy, makes it possible to argue that everything is, and will continue to be, under control. Action according to this worldview is, however, risky.

The assumption underlying the argument in this thesis is of another kind. Instead of relying on technological development alone, social change is the basis for the hope. In an era of tremendous development of information technology, society is changing quickly. It is quite plausible that the technological development will continue, and that it will be intertwined with social change. It is therefore of crucial importance to find out how this change can be made positive, and be directed towards solving environmental and other problems. This worldview is similar to what Costanza et al. (2000) call the "technological sceptic".

Statistics for Sweden show that energy use for internal transport has increased by almost 60 % since 1970. The increasing use of energy halted temporarily for a couple of years at the beginning of the 1990s, but a few years later it began to increase again (Energimyndigheten, 1999). The high use of energy for transport is a serious threat to sustainable development.

In urban areas in particular, other negative consequences of transport such as congestion and air pollution are also more difficult to handle with swelling traffic volumes. All these factors are nested, so that measures taken to reduce energy use may affect congestion and air pollution as well. Changes in transport volumes will be correlated with changes in the organisation of people's activities. Such changes can be considered as both positive and negative.

In this thesis, the main field of interest is urban passenger transport and the question of how this activity can be organised in a sustainable society. Other transport fields, such as long-distance transport and goods transport, are not in focus, but some of the main arguments regarding aim (sustainable development), methodology (future studies/backcasting) and conclusions (regarding the interplay between information technology, transport and land-use), are valid for these types of transport as well.

Sustainable development has been interpreted in many different ways. Sometimes it is used only to emphasise the importance of continued and steady economic growth. In other circumstances it is restricted to an ecological target. The operationalisation of the concept is dependent on how it is defined. Because of all the existing interpretations of the concept, there is a need to be quite explicit every time it is used. The concept is discussed further in Section 2 of this introduction.

A continued development along trends does not seem to lead towards attaining sustainable development in transport. Therefore, alternatives to the trends ought to be sought. It can then be reasonable to begin by looking at factors that are changing quickly and that can be presumed to have great importance for the future development of society. One group of such factors is information technology.

In this thesis, information technology is looked upon as a means, which is used for reaching the goal. The focus is then not the actual technological development. Instead, the various uses of the technology become more important. Information technology can affect transport in two essentially different ways. One is through the introduction of transport telematics[1] i.e. information technology used in traffic, examples of which are public transport information systems and dynamic route choice systems. The other is through effects on transport demand, mainly through effects on the location of activities, i.e. on the spatial structure of the organisation of society.

Much research on information technology and transport is centred on questions such as; How will IT affect transport? and How will transport change if teleworking becomes common? This way of asking questions implies a rather deterministic view of the future, which is common in some future studies approaches. It is however important to realise that the direction that can be seen in terms of trends and forecasts is not predestined.

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[1] An alternative term to transport telematics is intelligent transport systems (ITS). Intelligent vehicle-highway systems (IVHS), and road transport informatics (RTI) are two similar concepts that were common some years ago.

Here, the main question is: How can information technology help in the transformation of the transport system towards sustainable development? This way of formulating the question is quite typical in the so-called backcasting approach. It reflects a belief that the way information technology is used can and will shape the society. Therefore, the task is to find out how to use the new technology in a desired way. In earlier research the relationships between the different approaches have not been sufficiently explained or explored. Therefore, there is a need to further develop some methodological issues regarding backcasting methodologies.

The aims of this thesis are threefold. One aim is to further operationalise the concept of sustainable development. Another aim is to develop the backcasting approach and to clarify its relation to other approaches in future studies. The third, and maybe most important aim, is to deepen the understanding of the relationship between information technology and transport and to present scenarios of transport systems that are more in line with sustainable development than current systems.

1.1 The Structure of this Thesis

This thesis consists of an introductory part followed by reprints of Papers I-VIII. The introductory part can be read on its own merits. But it is also a summary of the findings of the papers that are included.

In this first section, a general background to the thesis is painted, and the aims are formulated.

In Section 2, the concept sustainable development is interpreted and developed further and some implications for transport are discussed. This section is based on a paper from Ecological Economics (Paper I). In the final paragraphs of the section, there is also a description of how the sustainable development concept is used in Papers III-VIII.

Section 3 is a methodological section where backcasting is discussed in relation to other forms of future studies. The section is partly based on a paper in Futures (Paper II). In the final paragraphs of the section, methodologies from Papers I-VIII are presented.

Section 4, on information technology and transport, is divided into three subsections, following the two different kinds of IT use mentioned above (4.1 and 4.2) and a synthesis of these (4.3). Subsection 4.1, on transport telematics, is dedicated to a presentation and discussion of a survey presented as a licentiate dissertation (Paper III) and in a paper in Transportation Research D (Paper IV). In the survey, four technical scenarios on the use of transport telematics in urban transport are generated and evaluated with the help of an expert panel.

Subsection 4.2 is dedicated to how transport demand can be reduced with the help of information technology in a more indirect sense. This subsection includes a discussion on different urban forms and their implications for transport volumes. It is argued that due to advances within the field of information technology, new conditions are brought into this analysis. The argument is founded on a section from a book edited by Snickars et al (Paper VI). The subsection also summarises some findings regarding transport, sustainable development and information technology from an edited volume of selected proceedings from a conference (Paper V). Finally, the subsection also summarises a conference paper on a node-oriented scenario (Paper VII). In the scenario, a kind of combined employment/residential nodes are defined in the Stockholm region and the potential effects of this on commuting are calculated according to some assumptions. Some of the ideas in Papers V, VI, and VII are related. However, in Paper V the scope is the whole transport system, Paper VI deals with commuting only and Paper VII provides a numerical calculation which attempts to make the ideas in Paper V and VI a bit more tangible.

In Section 5, some general implications from the introduction of information technology on sustainable development for transport are discussed. The arguments in this section can be seen as an extension of the discussion in the paper from World Transport Policy and Practice (Paper VIII). Finally, in Section 6 conclusions from previous sections are summarised and discussed.

2. SUSTAINABLE DEVELOPMENT

Sustainable development is still, almost fifteen years after the Brundtland Report, a concept that is widely used. It has become an accepted high-level policy goal which hardly anybody would oppose. One reason for the concept's success is no doubt that it is so vague, or at least that it has so many competing definitions. Despite (or thanks to) the vagueness, it is likely that the concept can continue to help keeping environmental sustainability and development issues on the agenda for decision-makers. However, there is also a need to keep the discourse on the contents of the concept alive. Otherwise, it risks at becoming not only vague, but also empty, as a high-level policy goal.

According to the definition in the Brundtland Report, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Principle 5 from the UNCED in Rio de Janeiro (1992) states that eradicating poverty is “an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living, and better meet the needs of the majority of the people of the world”. These statements indicate that sustainable development has to do with using the ecosystem in a careful way, limiting the differences in standards of living in the world and that this should be done with a long-term perspective.

One starting point when defining sustainable development in this thesis is Daly’s idea that sustainability requires that the human scale (throughput) is limited to a level which is at least within carrying capacity (Daly, 1991, p. 44). A related way of putting it is to say that sustainable development requires the preservation of the natural capital base at the present level (Costanza & Daly, 1992). Below, these definitions are developed in a couple of different ways.

First, in Daly’s and Costanza’s definitions the important issue of distribution of welfare is missing. One way of dealing with this could be to add a requirement on the distribution of resources (e.g. an equal per capita share) (Hunhammar, 1999, p. 15). This is a concrete way of incorporating the resource perspective into a distribution context, and it makes quantifying relatively simple. However, there are also disadvantages with this, namely that it hides at least one essential issue. In fact, sustainable development could be attained in a situation where 80 % of the world population is starving and the rest is prosperous, with that operationalisation. The explanation for this is that when the distribution requirement is formulated on the resource level, it does not account for differences in technology. Due to its more advanced technology, an industrialised country can get a lot more out of a certain resource than a non-industrialised country. Therefore, the population in an industrialised country can reach a much higher standard of living given the same resource input.[2]

Second, when Daly tries to operationalise the definition further, he concentrates solely on non-renewable and renewable resources (Daly, 1991, p. 44), which is equivalent to relating all nature’s values to scales and limits. However, some values such as biodiversity are not possible to define in such measures (Paper 1, p. 272). The criterion for non-renewable resources

[2] During a discussion on this issue, Hunhammar admitted that this is true when the concept “resource” is interpreted as a natural resource (which is the case in Hunhammar’s writings). However, Hunhammar argued that if “resource” were reinterpreted to include other resources, such as technology and know-how, his definition would correspond better with the intentions of the WCED and UNCED.

"…exploited at a rate equal to the creation of renewable substitutes" is formulated to be suitable for minerals and metals rather than for diversity of organisms. Furthermore, the criterion for renewable resources is composed to suit reproductive elements of nature. Biodiversity falls into neither of these categories.

Third, the definitions above mainly analyse sustainable development from an ecological perspective. However, according to both the Brundtland Report, and the UNCED, sustainable development is to be conceived as an aim which is broader than just the ecological.

Sustainable development is here considered as a goal. This implies that environmental issues are important, but it does not mean that non-environmental issues are unimportant. Instead, the use of the concept sustainable development is to be taken as an indication of a wide starting point.

In Paper I, we have tried to take the operationalisation of sustainable development one step further, without having to reduce the concept as much as in the examples above. We suggest four principles for sustainable development (see Table 1). We call two of these sustainability principles and two of them development principles. The first two have a longer time perspective, while the last two relate to the present. The first principle is S_a – preserving the natural resources for future generations. It is based on Daly's ideas referred to above, but it is expanded to also include biodiversity. The second principle, S_b – preserving the option value of human and man-made capital for future generations, concerns the issue that knowledge and infrastructure should not be destroyed in attempts to fulfil the other three principles. However, it also indicates the opportunity to change the means by which a value is fulfilled. The third principle, D_a – improving quality of life for individuals, includes different welfare measures such as life expectancy, literacy and freedom for the present generation. The final principle, D_b – ensuring a fair distribution of life-quality, reflects the need to keep distributional aspects in mind, such as fair distribution among nations, population groups and sexes.

Sustainability	**Development**
S_a – preserving the natural resources for future generations	D_a – improving quality of life for individuals
S_b – preserving the option value of human and man-made capital for future generations	D_b – ensuring a fair distribution of quality of life

Table 1: An expanded set of principles for sustainable development (Paper I, p. 273).

Now, looking at the transport system with the four principles in mind, it is obvious that S_a is a principle with implications for transport. Transport is almost entirely dependent on fossil fuels and that would have to change completely in order to make transport comply with this principle. This is a requirement that is seen by many as maybe the most challenging task for future transport.

S_b is a less concrete principle. It demonstrates the importance of not ruining existing capital, but it also points out the *opportunities* to achieve values by new means. Thus, it emphasises that investments in transport infrastructure should be valued according to the service they can provide and not according to the money that has been spent on this historically. The principle thus opens the way for solutions to transport related problems outside the traditional transport field, e.g. it demonstrates that in some cases it can be possible to exchange the value of physical mobility for access through information technology.

D_a illuminates the complicated relationship between mobility and welfare. Increased opportunities to travel for an individual provide higher accessibility to services if nothing else changes. However, when this increased mobility is a reflection of higher car use, it also includes social costs in terms of e.g. automobile dependence and less attractive cities. At an aggregate level, it is quite possible that increased mobility for some reduces accessibility for others. This is what happens when services that require car access drive other competing businesses out of the market.

D_b has at least two different aspects, one on social groups and one on regions. At the group level this principle demands a fair distribution of accessibility. In Paper I, it is argued that the use of cost-benefit analyses to justify infrastructure investments tends to favour affluent population groups. D_b also identifies the fact that there are huge differences in transport use between regions. Many people from the affluent part of the world have a tremendous possibility to go to almost any other place they can imagine and the variety of goods available in affluent societies is endless. The inequalities in transport between regions are merely reflections of the global inequalities and cannot be resolved within the field of transport policy. They can only be treated as a part of a more general redistribution of wealth.

2.1 Sustainable Development in Papers III-VIII

All papers in this thesis (except perhaps Paper II) make explicit use of the sustainable development concept. In the papers on transport telematics (Papers III and IV) and in the World Transport Policy and Practice paper (Paper VIII), the interpretation of sustainable development is explicitly based on the principles in Paper I. The definition is used as a tool to keep a certain width in the evaluation of the various scenarios in the papers. Paper VIII includes a first attempt to relate all four principles to the effects of the scenarios in the survey reported in Papers III and IV.

In two of the papers which deal with more indirect effects of information technology on transport (Papers V and VI), the requirements of a sustainable transport system are interpreted in terms of reductions of fossil fuels and in terms of equal per capita share of resources (Hunhammar, 1999, p. 15). In Paper VII sustainable development is not explicitly discussed, but VII is based on Papers V and VI, and therefore it has the same starting points. Thus, the challenge in these papers was to find out what society could look like if severe restrictions were imposed on energy use.

3. FUTURE STUDIES

3.1 Contested Concepts

The papers in this thesis belong to the field of future studies. Definitions in this field are often vague and when not vague, important concepts remain essentially contested. Therefore, this section begins with a presentation of some other authors' definitions of some important concepts, and an explanation of how they are used in this thesis (see Table 2 below).

Makridakis et al. (1998, p. 3) state that forecasting applies to non-controllable external factors, decision making applies to internal factors, and planning is the link between forecasting and decision making. Makridakis et al. do not go on to define these concepts further, but other researchers do.

Van der Heijden (1996, p. 6) also emphasises the distinction between internal and external. He finds it important to differentiate between the organisational self (where the strategist has control), the transactional environment (where the strategist has influence) and the contextual environment (where the strategist has no influence).

One definition of forecasting is given by Rescher (1998, p. 42). He first defines prediction as "a question-answering process that involves a commitment regarding what will or will not happen – be it categorically or under certain conditions". From this Rescher goes on to define a forecast as a specific sort of prediction which is not conditional, not general and not probabilistic.

When discussing descriptions of future developments or states, Johansen (1977) distinguishes between projections, forecasts and plans. In Johansen's terminology, projections are descriptions of future possible states or developments, without reference to probability or intentions to reach these. Forecasts are descriptions of future states or developments, which are considered to be expected or probable. Plans are descriptions of future states or developments, which express an intention. Moreover, forecasts are divided into conditional and indicative forecasts. The former are "intended to be valid … only on certain conditions without implying anything on the likelihood of these conditions being fulfilled". Indicative forecasts are "intended to influence – through the very elaboration and announcement of the forecast – the state or development which is being forecasted" (Johansen, 1977, p. 125).

Minzberg, (1994, p. 12) in an overview of different definitions of planning argues that "Planning is a formalized procedure to produce an articulated result, in the form of an integrated system of decisions". Minzberg distinguishes between strategy and planning, arguing that one important task of planning is to formalise strategy, where strategy is an idea about a suitable direction for future development.

There are a number of different forecasting methods in common use reviewed by for instance Makridakis et al. (1998) and Rescher (1998). One group of such methods, which is especially common in long-term future studies, is scenario methods.

According to Makridakis et al., "scenarios are attempts to visualize a number of possible futures and consider their implications". They claim that a "major purpose of scenarios is to challenge conventional thinking and avoid extrapolating into the future in a linear fashion" (Makridakis et al., 1998, p. 472).

Van der Heijden seems to be of about the same opinion. He states that "scenarios are a set of reasonably plausible, but structurally different futures" (van der Heijden, 1996, p. 29). This is to be taken as something completely different to the way scenario planning is sometimes used, namely "to indicate a method of traditional decision analysis" (van der Heijden, p. 28).

Von Reibnitz says that "a scenario approach involves developing future environment situations (scenarios) and describing the path from any given present situation to these future situations" (von Reibnitz, 1988, p. 15).

And according to Mintzberg in scenario building "… alternative views of the possible states of an organization's future environment are postulated" (Mintzberg, 1994, p. 55).

Masser et al. state that “Scenarios are descriptions of future developments based on explicit assumptions” and that “scenario writing as a group exercise has the potential of generating awareness of factors and impacts which may not have been identified through formal forecasting methods” (Masser et al., 1992, p. 4).

From the definitions above, it should be clear that scenario methods are often used as a “softer” alternative to other forecasting methods. The examples come from literature mainly involved with future studies in business. In such cases, scenario methods are recommended as a way of preparing the enterprise for alternative futures. However, scenarios can also be used to investigate and present options.

In more conventional forecasting, the outcome is a prediction conditioned by some external factors. In explorative scenarios no prediction is made. Instead a number of different external scenarios are explored in order to try to find strategies for the choice of internal factors that are as independent as possible of the outcome of the external factors. They are “...exploration trips into an unknown future” (van der Heijden, 1996, p. 221). Wack (1985a, 19985b), with examples from the Royal Dutch/Shell group, uses the concept decision scenario for a similar type of scenario, but he puts more emphasis on how the actual scenario is used in decision making. Wack also specifies that the point with these kinds of scenarios is to find out which factors can and which cannot change. He argues for a consequent search for the critical factors that may change the terms on which a company is competing.

It seems that scenarios are sometimes regarded as descriptions of a future *development* and sometimes as descriptions of some future *state*. In the latter case, no description of the development path from now to the future point in time is given. This latter sort of scenario is sometimes called an image of the future.

Definitions of concepts

A summary of the concepts discussed above is presented in Table 2. The table lists how the concepts are defined in this thesis.

Concept	Definition
Future studies	the exploration of future states or developments and the study of how these explorations can be used in planning and strategy formation
Forecasting	a process that applies to non-controllable external factors, and which involves a commitment regarding what will or will not happen – be it categorically or under certain conditions
Planning	a formalised procedure to produce an articulated result, in the form of an integrated system of decisions
Scenarios	attempts to visualise possible future states and/or developments
Scenario studies	the generation of scenarios and consideration of their implications
Vision	a distant high-priority target, or group of targets, which seems to be difficult to reach
Explorative scenarios	the use of scenarios for exploration of effects of several possible outcomes of external factors

Table 2: Definitions of basic concepts.

Future studies is here the exploration of future states or developments and the study of how these explorations can be used in planning and strategy formation. The aim with future studies is to get a better understanding of future opportunities. This understanding can be used either to adapt to the future or to try to influence the future. These two seemingly opposite ways of use can be overlapping, since trying to adapt to the future will (hopefully) affect the outcome.

Rescher's (1998) distinction between forecasting and prediction is quite opposite to some other definitions but his emphasis of prediction as a process is attractive. The way he defines prediction is actually a possible way of defining forecasting. The statement by Makridakis et al. (1998) that forecasting applies to external factors is also important. Combining these two definitions describes *forecasting* as a process which applies to non-controllable external factors, and which involves a commitment regarding what will or will not happen – be it categorically or under certain conditions.

The Minzberg (1994) definition of *planning* is used as it is here: "Planning is a formalized procedure to produce an articulated result, in the form of an integrated system of decisions". In this way, a distinction between forecasting and planning is achieved.

The definition of scenario that is proposed here is a combination of some of the definitions above: *Scenarios* are attempts to visualise possible future states and/or developments. *Scenario studies* are the generation of scenarios and consideration of their implications. With this definition, the emphasis is on the scenario as a tool to visualise futures. Another important feature is that it allows descriptions of future states and/or developments. This makes best sense with the way the word is usually used.

A concept that is related to scenario and to image of the future is *vision*. A vision is henceforth a distant high-priority target, or group of targets, which seems to be difficult to reach.

Explorative scenarios are scenarios used to explore effects of several possible outcomes of external factors, in order to be able to prepare for alternative developments.

3.2 Backcasting in Future Studies

One way of studying the future is to look at empirical data and then make assumptions of continuity (Makridakis et al., 1998, p. 9), claiming that empirically discovered relationships are valid in contexts other than those where the data was collected. In Paper II, four well-known forms of empirically discovered relationships are scrutinised. The first is historical cycles of infrastructure and other development (Grübler, 1989; Toffler & Toffler, 1995). In one case the assumption is that development can be described in waves with accelerating speed, so that society moves from one era to the next with increasing speed. In another case, there is an assumption of cyclic behaviour of transport infrastructure dominance during the past 150 years.

The second relationship is the presumed historic correlation between transport and communication growth, based on data from France 1835-1985 (Grübler, 1989). The third is the law of constant travel time, stating that the time used for travel is stable over time and between population groups and travel mode (Zahavi & Talvitie, 1980). Finally, the fourth is the gasoline-density relationship claiming that there is a relationship between petrol use and population densities in cities (Newman & Kenworthy, 1989).

A close examination of the relationships discussed by the above authors reveals that there are serious shortcomings in data, in interpretation of data and/or in analysis of the underlying causes of the relationships (Paper II). It is therefore concluded that forecasts based on these relationships have little value when preparing for the future if they are based purely on empirical data, without including any, or sufficient, analysis of the forces behind social change and the interpretation of the data. The use of these approaches means implicitly that strong assumptions of continuity are made. Images generated from these approaches tend to presuppose deterministically predictable behaviour, instead of encouraging a search for factors that could change the relationships disclosed. Forecasting should be done in a more analytical way, and be based on more explicit assumptions. One forecasting method that can be powerful in displaying the consequences of different actions, provided some conditions are fulfilled, is mathematical modelling (Paper II).

Backcasting is another future study approach that is anti-deterministic (Dreborg, 1996; Robinson, 1982; Robinson, 1990; Paper II). Backcasting is developed for use in situations where there exists a long-term target (e.g. sustainable development) that does not seem to be fulfilled according to ongoing trends. The incorporation of targets into the analysis makes backcasting an explicitly normative approach. The rest of this section is devoted to a discussion of the relationship between forecasting and backcasting.

The process diagram in Figure 1 gives a simplified way of looking at the decision situation from a rationalistic viewpoint. Below, the diagram will be used to illustrate the relationships between backcasting and some other approaches in future studies. It is an illustration of the environment in which an agent's policy is being formed. In the scheme, internal policy is distinguished from external factors. The combination of these will affect the resulting state, through the structure and functioning of the economy. Finally, the resulting state is valued on a preference scale. The preference scale can be multi-dimensional, in which case there will be several preference scales.

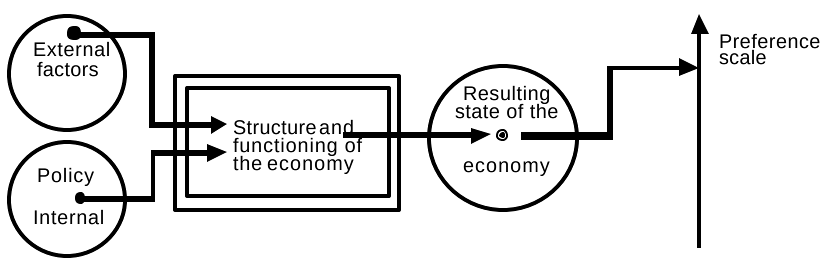

Figure 1: A decision-theoretic process. Simplified version of a diagram by Johansen (1977, p. 62).

The process diagram can be developed to include more than one agent. In such a case, there will be more than one set of internal factors. There will also be several different (sets of) preference scales, indicating that the agents can have different aims, and therefore value the resulting state differently.

Dynamics can be introduced into the process by defining that the exogenous factors, policy and resulting state refer to all time periods of consideration.

This makes the set of possible policies dependent on the previous state and thus indirectly dependent on previous policies and external development.

One common opinion is that forecasting belongs to external factors (see e.g. the comment on Makridakis et al., 1998, above). Much emphasis is therefore spent on revealing the external factors that are expected to be most important for the issue at stake. The external factors are independent of actions taken before the point of time studied. This is a consequence of a strict definition of external factors. Only when the external factors have been identified, and assumptions for the development of these have been made, can the development of the internal factors be analysed. Therefore, the analysis must stay within the boundaries set by the external factors.

In backcasting, on the other hand, no distinction is initially made between internal and external factors. This is equivalent to treating just about every factor as internal. The point of this is that it keeps all solutions open while studying the problem, and this may be wise, since in practice it can be difficult to know which factors are external.

The first task in backcasting is to define a vision, i.e. to set up a target. In the language of Figure 1 this is to state that the outcome must reach certain levels on the preference scales. The choice of vision, both quantitatively and qualitatively, is a normative task. In practice, it is possible to work with several types and levels of the target at the same time. This can be a way of reflecting the difficulty in reaching consensus on long-term targets. When the vision has been defined, it is compared to a forecast of the expected development. Thus, forecasting has an important part in the backcasting approach. Only if the forecast indicates that the goals will not be met ("1" in Figure 2), does the study continue with the next step. This is where scenarios or images of the future which fulfil the targets are generated and the effects of them evaluated ("2" in Figure 2, and "resulting state" in Figure 1). Then, when some resulting states have been found that fulfil the targets, the paths towards these states are investigated ("3" in Figure 2).

In this investigation, the distinction between external and internal factors is not important. It is more important to see which factors are crucial for the fulfilment of the target. Evidently, the reason for this is that the main applicability of backcasting studies is when the problems at stake are great and trend breaks will be necessary to find their solution. In such a case it may not be wise to define what are internal and what are external factors in advance. Instead, one idea with the backcast is to identify factors that may be crucial for reaching the targets. Displaying these factors can be an important result of the backcasting study. In a corresponding forecasting study, it is possible that some of the factors that are found to be crucial would have been defined as external and thus would have fallen outside the possible set of options. This does not mean that trend breaks can only be analysed with the help of backcasting. One forecasting approach that can be used to study the effects of trend breaks is explorative scenarios.

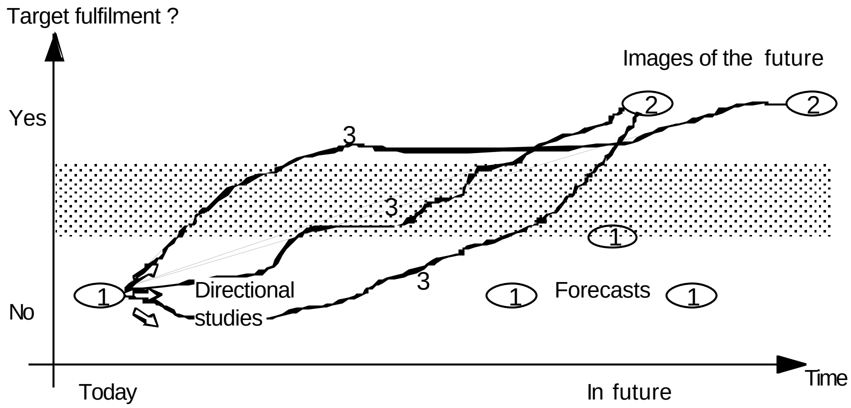

Figure 2 (from Paper II): The backcasting framework. Forecasts and directional studies indicate that the target will not be met (1). Therefore, scenarios that do fulfil the target are generated with the help of a suitable scenario method (2). Finally, the paths between the current situation and the scenarios are analysed, e.g. by means of different kinds of mathematical models. The shaded area in the figure represents states where the targets may be reached. Both the scale and the unit of the yaxis, 'target fulfilment', are explicitly normative. The figure is developed from Steen and Åkerman (1994).

Explorative scenarios (see Table 2) have similarities to backcasting scenarios. Just like backcasting scenarios, they are "...exploration trips into an unknown future" (van der Heijden, 1996, p. 221) but there are two distinctive contrasts between them. The first is that backcasting scenarios are scenarios over the whole future system, not only over external factors. This has to do with the previously mentioned characteristic of not paying so much attention to the division into internal and external factors. The second contrast is that backcasting begins with the formulation of a target, while in explorative scenarios, the idea is simply to "…explore *possible* futures" (van der Heijden, 1996, p. 222, italics added). With Johansen's (1977) terminology from Section 3.1 above, it can be said that both forecast scenarios and explorative scenarios are conditional, while backcasting scenarios are indicative.

In summation, backcasting studies try to keep as many opportunities as possible open for as long as possible. This may lead to some extra work and other delimitation problems, compared to forecasting, but it can also give some new insights and it may display options that would not have been found with other future studies methods. Even if displaying the options is not enough, it may be the first step towards actually affecting the development of some factors and challenging an undesirable development path.

From the discussion above it should be clear that the choice of methodology is a reflection of the aim of the study. Forecasting can be used when the aim is to adapt the decisions over internal factors to probable developments of external factors. Explorative scenario techniques are appropriate when the character of the external factors is known but the uncertainty of their values is great. In such cases explorative scenarios can be used for example to find strategies that minimise risks. Backcasting is motivated when there is a target, when forecasts indicate that this target will not be met, and when the changes needed to reach the targets seem to be beyond the scope of current policy.

Backcasting is sometimes criticised for being normative and political, due to the fact that it begins with targets and due to the fact that external factors are not defined initially. The response to this criticism is that the target setting is indeed explicitly normative, but that it is sometimes necessary to try to evaluate the consequences of explicitly stated targets that are difficult to reach. The choice of external factors is indeed also normative. It can be called political, but it is important to realise that *any* choice of external factors is normative. The right to define what is external, and thus unchangeable, is indeed a powerful task. In fact, a feature of backcasting is that it explicitly states the points of departure, and that it can be used to display weaknesses of narrow-minded and short-sighted planning.

One reason for the criticism might be that backcasting is looked upon as what Mintzberg calls enactment planning (1994, p. 245). However, enactment planning is (very crudely) based on the idea that a plan can be made and then enforced in an approximately similar way to that tested in the command economies. However, backcasting is a scenario approach, not an operational planning tool. Backcasting scenarios are not plans. They are merely illustrations of possible futures, which is something quite different.

3.3 Research Methodology in Papers I-VIII

The backcasting approach is not used in Paper I. Instead this paper is an analysis of concepts, mainly based on the literature from the field of ecological economics. Paper II is a methodological paper on the backcasting approach, but it does not really make use of a backcasting approach.

In Papers III and IV, a methodology named Backcasting Delphi was developed. The Delphi method is a structured way of using expert judgements on issues regarding future development. It originated from the

RAND Corporation with attempts in the field of technological forecasting. The Delphi method can be said to be a multi-round expert survey with the aim of reaching consensus among the experts regarding the development of certain key factors. The questions in the surveys are quantitative resembling the ideas of general survey methods in the social sciences.

In Papers III and IV, the Delphi method was adjusted to suit a backcasting approach, and to handle some of the criticism that it has received (Asplund, 1979; Sackman, 1974). In the survey in question, four strongly structured technical scenarios on urban passenger transport were developed. The scenarios were based on a number of technical functions that already exist, or at least that are discussed in the literature. The point of putting them together is that it is easier to see the use and effects of functions when they are presented in a context. Similar ideas, but with the use of policy measures instead of technical functions, have been used elsewhere to evaluate policy measures collected in packages (Banister et al., 2000). In another study the idea of packages is developed further (Åkerman et al., Forthcoming). The study defines measures that promote environmentally benign alternatives, that reduce the use of less environmentally benign mode,s and that increase the efficiency of transport. It is then argued that in order for a policy aiming at better environment to be successful, measures from the two first categories must be suitably coupled.

The Delphi experts were asked to evaluate among other things the feasibility and long-term effects of the scenarios. The feasibility evaluation was divided into two parts. In one the technical feasibility was evaluated. In the other, the question was whether the public would accept the scenarios. The experts' task was both to state how they assessed the scenarios and to suggest improvements to them. After a first round with about 80 responses out of 300, the scenarios were slightly modified and the questionnaire accordingly adjusted. Then the experts were asked to repeat their evaluation. For more details on the content of the study, see Papers III and IV.

The backcasting element in the survey is most clearly seen in the starting point. The aim of the various scenarios was to make transport more sustainable, in the sense stated in Paper I. The structured scenario technique was inspired by Delphi methodology. However, no attempts to reach consensus were made, and the experts were merely used to provide creative inspiration and to point out weaknesses in the scenarios. Thus, the result of the study is not to be looked upon as a prediction.

In Paper V, the setting of the study is based on a conditional statement, that if sustainable development (according to a given definition) is desired, then this can be operationalised according to certain subgoals. The subgoal that is expected to be most difficult to reach is the one relating to reductions of anthropogenic greenhouse gas emissions. By combining forecasts on future supply of renewable energy, technological development and traffic volumes, it is concluded that it is unlikely that technological development alone will be enough to reduce the emissions sufficiently (see Figure 3). Other measures are needed as well. Therefore images of sustainable futures are developed.

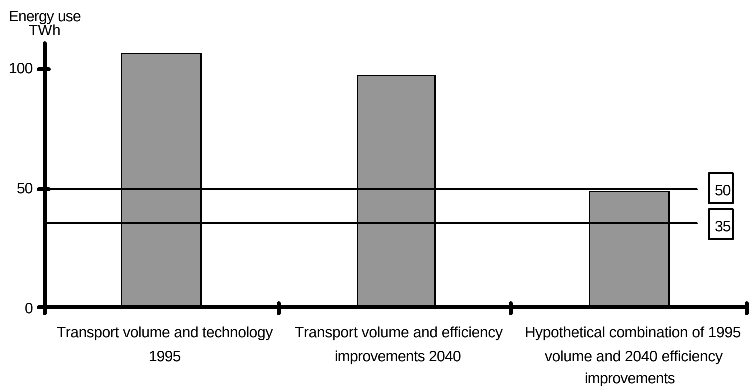

Figure 3 (from Paper V): Energy use in the transport sector. The left-hand column indicates present-day (1995) energy use in the Swedish transport sector. The middle column builds on forecasts of expected increases in transport volume in combination with a realisation of estimated technological potential. The right-hand column indicates the transport volume of 1995 in combination with a hypothetical realisation of the technological potential presented in Paper V. The figure shows the two assumed levels for sustainable energy use (35 TWh and 50 TWh) in the transport sector that were used in Paper V.

Paper VI provides a deepening of a part of the scenario in Paper V. It is thus based on the same presumptions. The scenario in Paper VI is inspired from the literature in mainly two different fields of research, transport and urban form, as well as information technology in organisations.

The basic assumptions underlying the scenario in Paper VII derive from Papers V and VI. In this way, Paper VII can be seen as a part of a backcasting study. The actual calculation of effects on commuting in the scenario is rather straightforward. The reference data come from origin-destination matrices for commuting in the Stockholm region 2010, generated by a traffic analysis model. In the scenario, an urban structure characterised by a network of nodes is implemented. In the calculation, this is interpreted in terms of a number of assumptions, which are used to calculate the effects on commuting in relation to the reference data for the regions in 2010.

4. INFORMATION TECHNOLOGY

In his three volumes on the informational age, Castells (1996, 1997, 1998) tries to capture the essence of today's society. He concludes that information technology affects just about every part of our daily lives. Due to this, he calls the age we live in the informational age, an age that has taken over from the industrial age, and where the whole of society is influenced by the new information technological paradigm (Castells, 1996).

Information technology can be important for transport in two different ways. The first is direct and involves technology related to the actual use of the transport system. Examples of such technology are navigation systems for drivers, information systems for public transport users, systems for dynamic road user fees and systems for more efficient goods transport. This technology is hereafter referred to as transport telematics and is treated in Section 4.1 below.

There are also indirect effects of information technology on transport. These indirect effects are by definition less straightforward, but they have to do with the general changes in society that relate to information technology. For example patterns of contact and location of activities are affected by technology, and these are elements which are of central importance for the transport demand and traffic activities. Section 4.2 is assigned to these indirect effects.

It could also be argued that the actual effect of information technology on the economy at large which then affects the traffic in terms of e.g. volumes and mode choices. However, this is a broader issue that is beyond the scope of this thesis.

It is plausible that a certain kind of urban spatial structure is better suited to some transport systems than to others. This is an issue that is discussed in Section 4.3, in relation to the urban structure in Section 4.2 and the transport systems in Section 4.1.

4.1 Transport Telematics

The direct effects of information technology on transport have been investigated in a scenario study on transport telematics in urban passenger transport (Höjer, 1999; Papers III and IV). The aim of the study was to investigate the kinds of IT-systems that can be designed to help adjust the urban passenger transport system to sustainable development. Four technical scenarios of urban transport systems were generated, basically from the literature. In addition, experts were asked to evaluate the scenarios in a two-round survey, as described in Section 3. Each of the scenarios had its own characteristics as elaborated below.

Car Pooling[3] was designed to show how information technology could raise the vehicle load factor, i.e. the number of passengers per car. A traffic control centre matched orders from travellers who desired a lift with drivers who were prepared to give one. All communication went through terminals connected to the centre. A route guidance system was used to direct drivers to the place where passengers were waiting. The passenger paid the driver for each trip with the use of a smart card and a card reader in the car. Road user fees were paid in a corresponding way. Some of the basic ideas for this scenario come from a vision in the Nordic Road Association (1992). The complete scenario description can be found in Paper III (p. 27).

Dynamic Route Choice was designed to optimise the performance of the urban transport system with the help of dynamic road user fees. The cost for each trip was calculated in advance by a traffic control centre. The fees depended on a number of factors (e.g. congestion, air quality, and place). The driver was given the opportunity to choose between the cheapest and the fastest (more expensive) routes. If one of these were chosen, the driver was obliged to follow instructions from a route guidance system and the charge was drawn from the smart card. The driver could also drive without instructions, but at higher road user costs. A pocket terminal could deliver information about projected costs and travel time before the driver got into the car. Lind (1997) has described several essential functions for this scenario. The complete scenario descriptions can be found in Paper III (p. 37 and p. 41).

Extended Public Transport was aimed at raising the attractiveness of public transport by improving information and extending the public transport information service to include taxis and rental cars. Public transport users could use a pocket terminal, connected to a traffic centre, to get information about possible connections between any two addresses in a region. The information contained approximate departure and arrival times, travel cost and changes. From the terminal it was also possible to reserve a cab or a rental car, in which cases a car would be waiting at the public transport destination. Road user charges for road transport were here used to encourage public transport use. Among other features for cyclists, a route guidance system for bicycles was included. The Cabinet Office (1995) has

[3] Car Pooling is not to be interpreted as people participating in a car pool. Instead, it is the actual car trip that is in the “pool” here.

described a related scenario. The complete scenario descriptions can be found in Paper III (p. 53 and p. 56).

In Dual Mode, the challenge was to combine the potential for efficient energy use in rail transport and the advantages of electric vehicles with the flexibility of the private car. This approach differed from the others in that it was more futuristic, e.g. by the requirement of a new infrastructure of monorails and dual mode vehicles. A dense rail network and electric vehicles that could run both on rail and on road were the physical foundations of the scenario. Trips could be made in a number of different ways (on road, automatic trips between stations in the rail network or combinations of these). A smart card was used for debiting the use of vehicles. It was also used for identifying users when a vehicle was hired and left the rail network. A traffic centre directed the flows on the rail network. User charges were lower on the rail network than on ordinary roads. Pocket terminals could be used to call for a vehicle when an automatic trip was demanded. The scenario is a version of a Danish system that is under development[4] (Jensen, 1996). The complete scenario descriptions can be found in Paper III (p. 65 and p. 69).

The Car Pooling-scenario was heavily criticised by the experts in the first round and was not repeated in the second round of the survey. Instead, some of the features from this scenario were incorporated into the Dynamic Route Choice-scenario of the second round. The results of the experts' evaluation of the scenarios are summarised in Table 3.

	Car Pooling	Dynamic Route Choice	Extended Public Transport	Dual Mode
Feasibility, main barriers	Acceptance barrier	Complexity barrier	No barriers found	Technical barriers
Market	Smaller cities	Same as today's car market	Same as today's public transport market	Same as today's car market
Effect	Reduced CO_2-emissions, not shorter travel times	Shorter travel times, some other positive effects	Many positive effects, longer travel times decreased comfort	Improved safety, some other positive effects

Table 3: Summary of evaluation of the four scenarios.

The Car Pooling scenario was rejected due to a belief that the presumed users would never accept it, mainly because they would not share a vehicle

[4] According to the RUF International (www.ruf.dk), the first test site is currently (June 2000) under construction in Denmark.

with strangers. Systems with less compulsory elements would probably be more feasible. Given the experts' high expectations on possible reductions of CO_2-emissions (Paper III, p. 32), it could be interesting to develop alternative forms of advanced car pooling.

The Dynamic Route Choice scenario was criticised for being technologically overloaded. Fears regarding the stability of the system were voiced. It was also revealed that the experts thought that the scenario could shorten travel times and that the economics of this scenario would be better than those of the others.

The Extended Public Transport scenario was not expected to meet any major technical or acceptance feasibility barriers. Moreover, it received the best scores on several long-term effects and the investment cost was expected to be reasonably low (Paper III, p. 60 and Paper IV, p. 462).

Finally, the experts were not convinced that the new infrastructure in the Dual Mode scenario would be technically feasible. The scenario involves a number of technical uncertainties, but it also seems to be the only scenario with the power to change existing travel patterns. It may be worthwhile following the technical development of dual-mode systems in future, since a technical break-through here could lead to a number of positive changes in transport.

In summary, the experts in the study seemed to have a high regard for the potential of transport telematics. A great proportion of them see a potential for substantial improvements on a number of long-term environmental and other effects. It is also clear that the greatest effects are expected to come from a systematic introduction of transport telematics for public transport. This implementation can be financed by the use of dynamic road user fees, along the lines of the road pricing described in Dynamic Route Choice. Such fees limit the need for public transport subsidies in two ways: directly by the revenue from the road user fees, and indirectly through the higher prices on transport, which makes it feasible to raise user prices for public transport as well.

Thus, the study indicates how improved public transport with telematics could be systematically implemented. A conclusion is that future development and design of transport telematics should focus much more on public transport applications. This implies a shift in current development programmes.

4.2 Information Technology and Transport Demand

The indirect effects of IT on transport comprise changes in the character and volume of transport demand. These changes can come from e.g. changes in land-use and in the organisation of activities. These are issues treated theoretically in Paper VI, to some extent in Paper V, and Paper VII presents a calculation of potential effects of these changes on commuting trip volumes, according to some explicit assumptions.

Due to the fact that commuting is structurally enforced, the implementation of general policy measures, such as increased CO_2 tax, would in the short term probably lead to a higher cut in leisure travel than in e.g. work travel (Mills, 1998). If it is true that leisure trips generally are preferred to work trips, then alternative measures should be explored, in order to forestall a situation where high transport prices force people to reduce leisure travel. One such exploration, which is mentioned in Paper V and further developed in Paper VI, is based on a combination of multinuclear cities and network organisations.

There are both spatial and organisational elements that set the limits for commuting. The spatial elements are characteristics such as urban form and the degree of functional division of cities. The organisational elements encompass the organisation of enterprises and the conditions under which individuals lead their lives. Obviously, the spatial and organisational elements are internally dependent.

The issue of urban form and traffic demand is well documented in the literature. A short review of some selected literature is given in the report upon which Paper VI is based (Höjer, 1998b). The positive effects of reduced traffic in cities are many. Reduced traffic could give social, environmental, safety and health related benefits but the hitch is that there are also drawbacks with reduced traffic. The major drawbacks are reduced mobility and the related decrease in physical accessibility (see also Paper I, p. 275-276). Most of the literature on urban form and demand for commuting states that high-density cities and multinuclear cities have a higher potential for low energy-use in transport than dispersed cities. There is however not complete consensus on the issue (Ewing, 1997; Gordon & Richardson, 1997).

The transport energy use in the multinuclear city depends heavily on several factors. A low fuel price, good capacity in the road network, and bad matching in the housing and labour markets are factors that can make the traffic demand greater in multinuclear cities than in dense cities. The matching problems are mainly of three different types. First, the housing prices and salaries for the employed in an area may not match. Second, it can be difficult for households with more than one breadwinner to live near all work places. Third, it can be difficult to keep a short commute when changing to a new job, since most people change jobs more often than they move (Cervero, 1989; Höjer, 1998b, pp. 46-48 and 54-55; Paper VI, p. 4).

If the matching problems could be handled, multinuclear cities would have a good potential for offering a low-demand transport system. This is where the changing organisational forms in the informational age become interesting. They bring partly new conditions to the analysis of the relationship between urban form and accessibility to work. The information technology's ability to short-circuit space implies that a number of new organisational forms become possible for enterprises. This feature of making activities space-independent also gives flexibility in time. If no time for transport is needed for a change of activities, the necessity to organise activities in time is less important. This means that the flexibility in time-use that can be gained from information technology is actually a consequence of space-independence rather than on the possibility of making things simultaneously.

So far, the main interest from researchers on the relationship between transport demand and information technology has been directed towards teleworking, i.e. towards the opportunity to work certain days or part of days from home or from a telecentre, instead of going to an office. But according to surveys, calculations and projections, the effects on total traffic volumes from telework will remain low (Höjer, 1998b). However, there is more to IT-related organisational change than teleworking.

According to Castells (1996; 1998), the most important processes in the new economy, which he calls the informational-global economy, are productivity and competitiveness. Productivity is decided by innovation and competitiveness by flexibility. Therefore, economic units of every possible kind maximise innovation and adaptability. Meanwhile, the organisations are geared towards simultaneous adaptability and co-ordination. This is Castell's characterisation of the network enterprise (Castells, 1998, p. 341). The network enterprises are built up of flextimers and networkers with a variety of working arrangements. Work can therefore be characterised by co-ordinated decentralisation and individualisation of labour.

The network enterprises that Castells (1996; 1998) describes are so far rare but there are indications of how the transformation towards network organisations can take place. One indication is of course the change in the number of teleworkers. Another indication is the tendency for businesses to place certain parts of their service functions at a place independent of spatial distance to both head office and customers. Examples of such services are ticket ordering, switchboards and banking. A third indication is the development of networks for small and medium sized enterprises. In fact, even if much effort is spent on measuring the development of teleworking, the other two indications may be at least as important for the study of how network organisations are formed and how this relates to transport.

A continued development towards ever-weaker physical connections between the units in an enterprise may, in a long perspective, make a network organisation on the individual scale feasible. When the organisation is network-oriented rather than space dependent, the members of the network do not have to operate at the same physical place. This, together with decentralised organisation, may open new opportunities for a high-access city with low traffic volumes, and for the telecommunicator in the multinuclear city.

In Paper VI and Höjer (1998b), a scenario called the Telecommunicators' scenario is presented. This is in essence a scenario for commuting trips. It is built on the network society and on the multinuclear city. In the scenario, about 50 % of the work force have their workplace in a node/subcentre not far from where they live. These "nodeworkers" consist of both "networkers" who work in network enterprises, and service workers who offer services to everybody working in the node, living close to the node and to people just passing through the node. The networkers' jobs differ from what we are used to today. They have a fixed office, but the colleagues at that office do not necessarily work for the same enterprise. So the workmates are typically not colleagues, but could, of course, to some extent share education and occupation.

In the Telecommunicators' scenario the structurally enforced travel is low. The low volumes are primarily an effect of short trip lengths, and are not due to a low number of trips. Due to the shorter trip lengths, a change to a higher degree of walking and cycling is also possible. This scenario could perform better in terms of reduced traffic than earlier resembling attempts with multinuclear cities and mixed jobs-housing-service. The reason is that the high degree of nodeworkers opens the way for a reduction in the matching problems. The bad matching between salary and affordable housing could decrease when the workplace becomes flexible. The opportunity of finding a home close to the workplace of everybody in the family is greater if at least someone in the family can take a nodejob. And the problem with increased commuting distances due to job changes would at least not have to be a problem for the networkers. They have the opportunity to change jobs without changing workplace. In fact, they can also change workplaces without changing jobs.

The Telecommunicators' scenario could not be introduced today, since there are a number of prerequisites that are not fulfilled. The most basic one might be "the telecommunicating prerequisite", which states that people's ability to telecommunicate, i.e. to communicate through the use of telecommunications, would generally have to be almost as good as their ability to communicate face-to-face. There are other prerequisites as well, such as that today's space-dependent organisations would have to develop towards network organisations and that there would have to be space for offices for the new networkers in the nodes (Höjer, 1998b, Paper VI).

In Paper V, another scenario, called the Node scenario, is presented. This includes the same basic ideas as the Telecommunicators' scenario, but it is broader, since it includes all types of transport. The traffic volumes in Sweden 2040 according to the Node scenario have been tentatively quantified, see Tables 4 and 5. As mentioned in Section 33 above, the quantification is based among other things on assumptions regarding potential improvements in energy efficiency and energy supply and on forecasts regarding traffic volumes.

	1995 (billion passenger-km)	NODE 2040 (billion passenger-km)
Walking and Cycling	5	10
Car, combustion mode (<100 km)	65	8
Car, electric mode (<100 km)	0	10
Small electric city vehicle	0	10
Car, combustion mode (>100 km)	20	28
Bus (<100 km)	7	12
Bus (>100 km)	2	10
Ferry, 75% on passengers (20 knots)	4	3
Rail (<100 km)	4	8
Rail, 200 km/h (>100 km)	5	15
Air	20	12
Total, short distance	81	58
Total, long distance	51	68
Total	132	126

Table 4 (from Paper V): Passenger transport volumes by mode in NODE compared with 1995. The table has been extended to include volumes for walking and cycling, according to the report upon which Paper V is based (Steen et al., 1997).

Tables 4 and 5 show that the greatest changes in the scenario compared to 1995 would be that air travel, short-distance travel by car and goods transport would decrease, whereas long-distance travel by other modes would increase. In total, short-distance travel would decrease by one third, long-distance travel would increase by one third and goods transport would decrease by 40 percent.

	1995 (billion tonne -km)	NODE 2040 (billion tonne -km)
Lorry (<100 km)	7	5
Lorry (>100 km)	26	10
Rail	19	22
Ferry, 25% on goods (20 knots)	4	2
Cargo ship	100	55
Air	0.3	0.15
Total	156	94

Table 5 (from Paper V): Goods transport volumes by mode in NODE compared with 1995.

The underlying changes in short-distance travel come mainly from the reduced commuting as described in the Telecommunicators' scenario. The reduction in goods transport comes from dematerialisation, which can reduce the flow of materials, and from a reduction of transport distances. The major part of the reduction of air travel comes from reduced business travel. Business trips can be perceived as quite costly (at least in time), so if the ability to telecommunicate increases the benefit from business trips decreases.

The ideas regarding potential effects on commuting that are presented in Papers V and VI are made more concrete in Paper VII, which presents a calculation of potential effects on commuting volumes from a restructuring of the Stockholm region, towards a region characterised by its combined employment and residential nodes. The results point at a reduction in commuting trip volumes of 50 percent compared to a reference scenario for 2010 (see Table 6). This is equivalent to a reduction of 40 percent compared to 1997.

	T0	T1	T0, %	T1, %	T1/T0
Car	3,900,000	1,920,000	45%	47%	49%
Public transport	4,400,000	1,830,000	51%	44%	42%
Walking/cycling	300,000	370,000	3%	9%	126%
Total	8,600,000	4,100,000	100%	100%	48%

Table 6 (from Paper VII): Total commuting trip volumes (passenger kilometres) by travel mode for the reference scenario, T0, and the node scenario, T1.

A comparison between Table 6, where all distances are included, and Table 7, where only trips shorter than 10 km are included, reveals that the decreases in traffic volumes come almost entirely from shortening trips longer than 10 kilometres in the calculation in Paper VII. More explicitly, the number of trips longer than 20 km is reduced by 80 percent and there is an exchange of 10 percent of commuting trips for work from home.

	T0	T1	T1/T0
Car	776,000	801,000	103%
Public Transport	740,000	720,000	97%
Walking/cycling	281,000	362,000	129%
Total	1,800,000	1,890,000	105%

Table 7 (from Paper VII): Total commuting trip volumes (passenger kilometre s) for trips shorter than 10 km by travel mode for the reference scenario, T0, and the node scenario, T1.

The results from the study in Paper VI (Table 4) can be compared to the traffic volumes for distances shorter than 10 km in the scenario in Paper VII (Table 7). Such a comparison must be made with care, since the numbers in Table 4 include all kinds of trips and all trips in Sweden in 2040, whereas Table 7 includes only commuting trips in the Stockholm region 2010. Despite this, it can be noted that in Paper V, short distance travel by car is halved, short distance public transport almost doubled and walking and cycling doubled. In Paper VII car travel and public transport do not change much, while walking and cycling increase by almost one third for trips shorter than 10 km.

Thus, the two papers build on approximately the same basic idea with node structure and network enterprises for reduced commuting. However, it seems that they come to quite different conclusions on what the modal split would look like. This is even more so considering the fact that Table 7 includes data for the Stockholm region only, where the public transport share is relatively high. One conclusion from this is that the node scenario might attract more cars than was assumed in Paper IV.

4.3 Telecommunicators in Telematics' Scenarios – a Synthesis

The scenarios in 4.2 deal with the organisation and location of activities, while they are not much elaborated in the transport system that connects the various places. The four scenarios in Section 4.1 on the other hand are technical descriptions of urban transport systems, without much attendance to the surrounding urban structure. In reality it is quite plausible that different types of transport systems would be more or less suitable depending on the character in terms of location of activities of the city. It could therefore be interesting to compare the technical scenarios in Section 4.1 with the node structure in Section 4.2.

The questions in the survey reported in Section 4.1 were not formulated with the intention of evaluating exactly the city structure described in the scenarios in Section 4.2. However, they may still give an indication of how the scenarios match. In one question, the experts were asked to state which scenarios would be best and worst suited for several different trip relationships in a city (Paper III, p. 80). Six trip relationships were defined: within city centre, city centre to suburb, city centre to shopping centre, within suburb, between suburbs and finally suburb to shopping centre. In a multinuclear city, an idea is that the amount of trips within suburbs and within city centres would increase in importance, whereas trips to shopping centres and, to some extent, between suburbs and city centres would decrease. According to the evaluation in Paper III, p. 80, the scenario that fits best to this pattern is the Extended Public Transport-scenario, while both the Car Pooling scenario and the Dual Mode scenario have a bad match to the pattern.

A slightly closer look at the data from the survey shows that the Extended Public Transport scenario gets the best evaluations in all trip relationships. So the high scores on trip relationships seem to be partly a reflection of a general approval of the scenario. The experts were also asked to state which of the trip relationships would be best suited and worst suited to each scenario, i.e. compared to other trip relationships, instead of compared to other scenarios (Paper III, Appendix VI). It then turned out that all scenarios were expected to do best in trips between suburbs and city centre. The Car Pooling scenario and the Dynamic Route Choice were expected to be strong in trips between suburbs as well, while the Extended Public Transport scenario and the Dual Mode scenario got good evaluations on trips within the city centres.

The nodes in the cities in the scenarios in Section 4.2 form a network orientated city structure. This structure should be well suited for efficient public transport and a rather high degree of walking and bicycling. So the modes upon which the Extended Public Transport scenario are built are also the modes most accentuated in the node-based scenarios. However, it can also be argued that the node-based structure should be well suited for the Dual Mode scenario, with its network infrastructure. The more evenly distributed the transport demand, both spatially and temporally, the more competitive this system would be. The Car Pooling scenario and the Dynamic Route Choice scenario, on the other hand, would rather be complementing systems in multinuclear cities.

5. CAN IT MAKE TRANSPORT SUSTAINABLE?

In Paper VIII, the four sustainable development principles (see Table 1) suggested in Paper I are discussed in relation to information technology and transport. It is concluded that when it comes to the resource principle, S_a, “there is nothing in information technology that triggers a major shift from non-renewables to renewables” (Paper I, p. 48). However, information technology can be important for this principle in any case. The potential for a more efficient transport system through the use of transport telematics is one possible contribution. Another is that new transport modes, such as the dual mode, are made possible. In this way, a shift from fuel dependence towards electricity based modes can be made possible. Now, the net effects of such a shift will be dependent on the production of primary energy. A third possible contribution is that information technology may affect transport demand. This is the starting point for the Node and Telecommunicators' scenarios. The implementation of such scenarios may be made feasible with information technology. The net effects on the resource principle will depend on which of two developments becomes the stronger. One development is that information technology can make traffic more efficient from a resource perspective (as in the transport telematics scenarios) and thus contribute towards reducing demand for traffic (as in the Node and Telecommunicators' scenarios). The other development is that the technology can stimulate more traffic if traffic flows become more efficient and if social and business contacts turn global.

The second sustainable development principle, preserving the option value of human and man-made capital, S_b, constrains the solutions to the problem of attaining sustainable development to those that do not waste the option value of capital. In the scenarios in Section 4.2 a general ambition is to preserve option values through the use of information technology, while traffic volumes decrease. However, if traffic volumes decreased, and no alternative ways to keep e.g. broad networks of contact were implemented, an important value of the transport system would have been lost. Therefore, this principle would have failed.

The third principle, improving quality of life, D_a, has several implications for transport. For example, transport today brings about a number of negative health effects, through emissions of pollutants and noise. Moreover casualties and congestion are well-known traffic-related problems. Measures leading to a mitigation of any of these problems would be positive from the point of view of this principle. According to the experts' evaluation of the transport telematics scenarios, the effects of these would be positive. It is quite possible that the scenarios in Section 4.2 would be positive in this sense as well, since they are expected to have lower traffic intensity than today. On the other hand, there is more to quality of life than physical health. One issue that may be regarded as negative in all the scenarios in Section 4 is the dependence on information technology. This gives vast opportunities for control to anyone with the right skills. Making a firm statement on the net effects of the scenarios on this principle is not possible, since it would require aggregations of both different types of effects on quality of life-issues and different individuals' values.

The fourth and final principle, ensuring a fair distribution of life-quality, D_a, is a principle with implications for any social change. The change related to information technology is no different in this respect. In the Dynamic Route Choice scenario, car users pay much more for driving in urban areas than today. This means that it is mainly the wealthy who can afford to continue driving a lot. Thus, a shift in car mobility can be envisaged. Therefore, it will be crucial for the evaluation of this principle to determine how the money collected from the car users is distributed. Two of the other telematics scenarios are quite differently designed. In the Extended Public Transport and Dual Mode scenarios, substantial resources are directed towards investments for a general improvement in accessibility. In this respect, welfare will become distributed among a larger part of the population, by the very implementation of the system.

– Can IT make transport sustainable? is the unanswerable question asked in the heading to this section. Evidently, the response can be neither a firm yes, nor a firm no. Information technology alone naturally cannot make transport sustainable but it seems that information technology has the power to be an important element in a social change towards sustainable development. However, there is also reason to be aware that the technology can work in the opposite direction, taking urban societies further into unsustainable development.

6. WHAT IS THE POINT OF IT?

In the preceding sections, four principles of sustainable development have been presented. The principles represent an attempt to further operationalise sustainable development, by placing the four presumably most important parts of the concept at the same analytical level. No one of these principles is automatically superior to the others.

The relationship of backcasting to other future studies approaches has been investigated. It has been concluded that a special feature of backcasting is that it pays relatively little attention to the distinction between external and internal factors. This way more options can be kept open for a longer time in the analysis.

With a backcasting approach, the principles of sustainable development have then been applied to different groups of scenarios with a high content of information technology. One of these groups is transport telematics in the transport system. The other group is scenarios where the actual travel demand is the issue, i.e. factors outside the transport system. In practice, these groups are clearly dependent.

With the development of new technology, the possible changes of society widen. However, due to the speed of development, there is barely time to register the opportunities before they are gone. Therefore, as was mentioned in the introduction, backcasting studies such as those presented in this thesis may be of interest even with starting points other than sustainable development. The scenarios on transport telematics could be useful as illustrations of how technical systems of this type can be designed and what they can accomplish. They do not prescribe any changes in trip relationships. However, since all four of them include systems for road user charges, the volumes and spatial distribution of traffic would be dependent on the price structure.

The major difference between now and the Telecommunicators' scenario is the organisation of work. If the opportunities to work as described in the scenario materialise, the analysis of the relationship between jobs and housing will be based on completely new conditions. The Telecommunicators' scenario offers several presumably positive characteristics that just cannot be provided today. Evidently, there are also several disadvantages with the Telecommunicators' scenario. However, the existence of new opportunities signals that the balance between good and bad features has not been sufficiently examined. The multinuclear urban structure *could* in fact develop without changes in prices or preferences. The possible reduction in traffic volumes is one factor in favour of it. Other features that might be desirable in this scenario are the higher concentration of activities and services close to housing, more vivid and therefore possibly less frightening streets and parks and for organisations, a greater selection of labour. These presumably positive effects of the Telecommunicators' scenario should be balanced against the negative impacts of low daily travel. During this balancing, it should however be recalled that there are indications that drastic cuts in transport might be needed in the future. Therefore, a question to bring into the evaluation of the scenario is: "What are the alternatives?". It may then turn out that the alternatives that are usually examined have a much higher transport demand.

The other scenario that is discussed in Section 4.2 is also based on the node structure, but it includes long-distance travel and goods transport as well. It is hard to see how these groups of transport could be reduced to the levels suggested without changes in prices or preferences. Higher prices could come from higher green taxes, or higher fuel prices. Changes in preferences and attitudes could be either as an increased interest in places nearby, or as a greater environmental consciousness. Both could lead to reduced long-distance travel by air.

The ability to handle the new technology will be important in order to take advantage of services in e.g. the Extended Public Transport scenario, but it will be even more important in the Telecommunicators' scenario. The most fundamental part of the Telecommunicators' scenario is the network enterprise. And the possibly most crucial change that is needed to make the network enterprise feasible is that people must learn to communicate with the help of telecommunications just as well as they communicate face to face. This condition is what is here called the telecommunicating prerequisite.

Apart from being a prerequisite this condition also indicates a possible threat to the fairness principle of sustainable development. There is a risk that everybody will not be as good a telecommunicator. Even with a development towards ever more user-friendly technology, practice will be needed in order to learn how to use it. There is also an apparent risk that the availability of competent teachers and good technology will differ a lot between various schools and countries. This may well enforce existing social gorges between countries and between groups. This is an example of what Castells means when he states that: "… inequality and polarization are prescripted in the dynamics of informational capitalism, and will prevail unless conscious action is taken to countervail these tendencies" (Castells, 1998, p. 344).

It can be argued that the distributional aspect mentioned here is just the same old story as any distributional issue, but there may be reason to treat this separately from the others. It is sometimes argued that information technology brings equal opportunities to everybody. But if it is true that supply of teachers and technology is important, then caution must be taken. However, there is also hope. The encouraging part of Castells' analysis is that he believes that conscious action can reduce the negative consequences of the informational society. One such action could be to work hard for equal access to both the new technology and to training in telecommunicating.

It was concluded in Section 5 that information technology will play a role in the future development of the transport system, but that it is not clear whether this role will be positive or negative with regard to sustainable development. This indicates that there is a need for public debate and political decisions to promote the positive development path. When it comes to transport telematics, the findings in this thesis advise increased investments in public transport telematics, even though the expected gains of such measures have not been quantified here.

The Telecommunicators' and Node scenarios represent more radical changes of society, but they deserve to be taken seriously. Information technology has provided us with new conditions for work and leisure. It has the potential to bring accessibility to activities and services without physical mobility. This gives policy options that should be investigated and debated. What is known today is enough to start thinking of what is good and what is bad in the scenarios. The changes that are described would take a long time to achieve, so it may be high time to start. The point of it is that conscious action may make IT an important factor in the transformation towards sustainable development but without any action or with incautious action, IT may pull society further into unsustainability.

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