Available online at www.sciencedirect.com
SCIENCE DIRECT®
Journal of Cleaner Production 13 (2005) 841–851
Journal of Cleaner Production
www.elsevier.com/locate/jclepro

Backcasting and econometrics for sustainable planning Information technology and individual preferences of travel

Markus Robèrt

Department of Infrastructure, Royal Institute of Technology, Stockholm, Sweden

Received 24 March 2003; accepted 12 December 2003

Abstract

This paper develops a framework, building on backcasting from sustainable outcomes, or more sustainable outcomes, in combination with econometric modelling to arrive at the outcomes. To reach long-term successful objectives by introducing new transport alternatives or services, econometric modelling is suggested as a suitable tool for investigating the presumptive behaviour of key-players. In the need for deriving individual preferences, behavioural modelling can be applied as an essential "pathfinder" in the backcasting framework. The framework is discussed in relation to an office district outside Stockholm, where IT-companies provide efficient transport alternatives for their employees. The long-term vision among the leaders of the companies is to achieve an improved environmental profile, in parallel with reduced travel costs and improved working conditions for the employees, by offering alternatives to private car, taxi and long-distance travel.
© 2004 Elsevier Ltd. All rights reserved.

Keywords: Backcasting; Forecasting; Econometrics; Behavioural modelling; IT; Sustainability; Transportation

1. Introduction

This paper presents a framework applicable for achieving predetermined long-term goals in complex systems, where uncertainties of future individual behaviour play a central role. Backcasting and econometrics are synthesized in order to analyse the conditions for individual behaviour consistent with the vision of a long-term sustainable goal. The term "backcasting" refers to a planning approach that departs from a vision of future success, followed by "looking back" and seeking strategies to get there.

The author uses a backcasting framework where behavioural (econometric) modelling works as an instrument for deriving individual preferences and attitudes essential to the long-term sustainability goal. The framework is applied on an office district outside Stockholm, where IT-companies have set a long-term goal of reaching emission reductions and monetary savings from more efficient personal travel. The behavioural modelling provides information of ways to reach environmental and economic goals without deteriorating the employees' working conditions. Improved working conditions could, for instance, involve increased flexibility, cheaper means of communication and less tiresome travel to work.

In relation to this project, backcasting as a methodology for strategic planning is discussed. It relates to a conscious envisioning of desirable outcomes followed by a study of conditions and paths to reach such outcomes. Historical data and information are then utilized as providers of information on aspects that are important for backcasting. The backcasting methodology complements the forecasting approach, i.e. projecting historical data and information and trends into the future. A motivation for using behavioural modelling as a complement in the backcasting framework is presented, together with conceptual definitions.

In brief, the author seeks to capture such measures that can break old habits and induce substitutions of private commuting with telecommunications and more resource-efficient transport modes. An extension of this analysis is to study the substitution effects as a function

E-mail address: markus@infra.kth.se.

0959-6526/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jclepro.2003.12.028

of e.g. transportation taxes and subsidies. What is achievable with and without such external means? The outcome may be relevant suggestions for company policy measures that would encourage a sustainable use of IT. The relevance of modelling individual preferences and behaviour in a backcasting perspective for political decisions is also briefly discussed.

Some side effects of our current traffic systems, like traffic congestion, pollution, greenhouse emissions, accidents and costs related to such side effects pose very demanding challenges to society. Many believe that telecommunications will provide the solution of saving natural as well as monetary resources. There are two fundamentally different research questions linked to this issue:

1. *Can* IT serve as a resource saving utility for future travel?
2. *Will* IT serve as a resource saving utility for future travel?

The first question is easy to answer: IT (e.g. teleworking and videoconferencing) has the potential of saving large amounts of resources by exchanging certain transports and improving the logistics of others (e.g. carpooling and ride-matching). Furthermore, it is, in general, a less expensive and faster way to communicate. Empirical results [1,2] show the immense potential of lowering the environmental impact and saving money by efficient use of IT. For example, calculations show that videoconferencing at the telecommunication company Ericsson can save 3 million SEK per individual unit of equipment and per year [1]. Teleworking is therefore, also appealing to planners and politicians since it has the capacity to reduce commuting travel at no cost in terms of infrastructure [3,4].

The second question is more complex. Much of the early forecasts (starting in the 1950s [5]) are being criticized for deterministically drawing too optimistic conclusions [6]. The effects from implementation of IT in the society were described as if there were a direct link between the potential on the one hand and the actual outcome on the other. However, forecasting behavioural changes related to an increased use of IT is a difficult matter that incorporates a complex mixture of economic, sociological and technological aspects [7].

In fact, few of the forecasted positive effects have been empirically verified. For instance, studies made on video and teleconferencing suggest very modest trip reductions, or no impact at all on total travel distances [3,8–10]. Similar results have been documented for teleworking [11,12].

Other studies reveal a set of results indicating that IT—with its capacity to extend contact networks—will serve as yet another boost to the ever increasing transportation demand and might therefore, increase exploitation of natural resources [13–15]. Forecasts based on trends and time-series observations are used to estimate future aspects and characteristics affecting the choice to telework [16] and to predict emissions related to teleworking and use of information technology [17]. In contrast to early forecasts of the interrelationship between IT and travel, later forecasts indicate how the technology may work as a complement to extend contact networks further.

Toffler and Grübler [18,19] point at similarities in the historical expansion of other communication technologies, e.g. railways, roads and airways, which all led to an increased communication and travel demand. From this historical perspective, IT is believed to be likely to follow the same pattern—extending travel demand further. In turn, these forecasts of IT and travel interaction have been criticized as too *negatively* deterministic Höjer and Mattsson [20]. They term this approach as "an apocalyptic way of writing history" and that this "represents simplistic analyses which glance ahead without paying attention to the nuances". According to Höjer and Mattsson [20], forecasts relying too strongly on such historical parallels risk missing opportunities for changing present trends.

Apparently, question number 2 above has no straight answer. Probably something like: "it depends…" or "yes, under certain conditions…" would work as the beginning of a possible answer. The uncertainty of forecasts is related to the complexity of the social system we are studying. We see developments of new technologies as well as new cultural trends all the time. This implies dynamic changes in the conditions—IT is integrated in a complex web of human inventions, decisions and priorities. Rebound effects—feedback loops in the economy—may overcompensate the initial resource savings from the application of IT and make the final environmental resource use larger than before. In short, through a variety of complex interactions, telecommunications may induce more travelling more often than it works as a substitute for physical travelling.

Regardless of the accuracy of forecasts based on current trends, such studies are helpful to collect information about certain relevant drivers of societal development. In all attempts to plan ahead for a successful societal transition to sustainability, the results of such studies should be taken seriously. There is now a need for studies of a more problem-solving character. The questions presented above, *can* and *will* IT serve as a resource saving utility for future travel, seem to lead us to the conclusion that it depends on many aspects. Another, perhaps, more pertinent question to ask at this point would be:

3. *How* can IT serve as a resource saving utility for future travel?

First, different categories of travel-related IT-services should be considered. Golob [3] declares seven types of IT applications that are related to travel: (1) online shopping, (2) other online services, e.g. telemedicine,

(3) flexible working arrangements, e.g. teleworking, (4) self-employment, (5) contingent and part-time working arrangements, (6) mobile working, and (7) education. To date, little systematic research has been conducted on the areas above or how these possibilities could be used in conscious ways to solve societal problems, see [3].

In this paper one additional type of application is suggested to Golob's list: IT as a tool to consciously improve the logistics as well as attractiveness of more efficient transport alternatives. The impact of such IT-related efficiencies could be tested in the econometric framework discussed later in this paper. Examples of such inventions could be, e.g. web applications for car- or taxi-sharing to reduce underutilized vehicle transport. Another example could be a booking and payment system for carpooling, thereby, improving the attractiveness of substitutes to private car ownership or usage.

The empirical data in the research were collected from Nacka Strand, which is an office district outside the city of Stockholm where such inventions are implemented. Information on individual preferences, focusing on the valuation of the specific IT-services is provided from a survey distributed to the employees. The behavioural econometric models are based on these data.

In Section 2 the backcasting framework, its importance and relevance are described. In Section 3 econometric forecasting, including behavioural modelling aspects, are explained. In Section 4 the integration of econometrics, including behavioural modelling, within the backcasting framework is elaborated. In Section 5 the design of the Nacka Strand study is discussed, followed by three practical examples as a further foundation for Sections 2–4. In Section 6, the results are discussed and conclusions are presented.

2. Backcasting

A *backcasting* approach means to use future objectives—independent of current constraints and difficulties—as the perspective of planning in which the following questions are posed: "What shall we do today to get there, and what measures may lead into blind alleys and should be avoided?" [21]. In Section 5.2 the backcasting approach is demonstrated in three practical examples from this particular case study.

Backcasting is applicable in planning when the *desired* future is far away from matching forecasts of an *expected* future. Particularly when dealing with environmental problems the challenge is to find ways to break present trends and to test the feasibility of new paths along which sustainable development could take place [21].

Dreborg [22] pinpoints five situations where backcasting is particularly useful:

- when the problem is complex, affecting many sectors and levels of the society;
- when there is a need for major change, i.e. when marginal changes within the prevailing order will not be sufficient;
- when dominant trends are part of the problem as these trends are often the cornerstones of forecasts;
- when the problem, to a great extent, is a matter of externalities, which the market cannot treat satisfactorily;
- when the time horizon is long enough to allow considerable scope for deliberate choice.

Höjer and Mattsson [20] describe a practical example where a backcasting approach would help clarify the conditions whereupon teleworking would have a mitigating impact on current traffic volumes. They provide a hypothetical case where empirical studies on teleworking show little impact on travel reduction (actual examples of such studies were presented in Section 1). The problem formulation is described as: "With a backcasting perspective, the task would then be to find what changes in the design of teleworking, or other changes in current conditions, could make teleworking related options, more relevant?"

This example shows the idea of how a backcasting approach may free the analysis from the restrictions of current trends and instead lead to a study on how various policy aspects can be changed to promote pursuance of paths to comply with sustainability objectives.

Other alternatives than direct IT-substitutes, such as teleworking, are relevant to analyse from a backcasting perspective. Services like e-commerce, videoconferencing, and access to new, clean intercity vehicles and cars without ownership (e.g. carpools supported by IT) are all examples of potential trend-breakers [23].

From a backcasting point of view, all such ingredients can help mitigate the present dependency on private cars and are potential cornerstones in a future sustainable transportation system. Even though some of the new services might increase travel demand in the short run (because of increased attractiveness of the services), they may be meaningful to stimulate decreases in private auto usage, in the long run. This is, in particular, if policies are developed that can utilize the resource saving potential of the new technologies. Two complementary steps can be identified from Åkerman et al. [23]:

1. Stimulate more resource-efficient transport alternatives; in order to increase the utility of other transport means than car, "carrots are better than sticks".
2. When the new alternatives have been introduced, deal with later issues, e.g. try to avoid rebound effects and develop new services further in line with the objectives of the backcasting framework.

These two elements are incorporated into the backcasting framework, where behavioural modelling serves as a tool to find behavioural trend-breakers (Section 4). To develop this idea, first the backcasting framework is presented.

The backcasting framework is pictured below (Fig. 1). First the situation of today is analysed (e.g. a specific level of company emissions of greenhouse gases). Then the long-term desired goal of the future is sketched (e.g. an emission reduction target set for a specific date in the future). To reach the long-term goal from the present situation, there are several feasible paths (a, b and c in Fig. 1). These paths consist of e.g. policies and concrete measures bridging the gap between the future target achievement and the situation of today. The dashed line in Fig. 1 represents the threshold level for target achievement. Below this level the long-term goal is not fulfilled.

In this study, the long-term goal consists of two dimensions: (a) the individuals' perceived benefit throughout the transition period and (b) reducing the companies' travel-related emissions within or below the company's previous travel expenses.

2.1. Emission targets in consistency with individual preferences

Scenarios based on physical resource calculations show that a reduction to 0.2 ton CO_2 emissions/capita from today's 2 ton/capita would imply an acceptable risk-level in the context of Sweden's contribution to the greenhouse effect [25]. A less radical emission target would be to reach the European Union's reduction goal of 8%. This is not a sufficient emission level from a long-term sustainability point of view. However, over shorter time frames such less drastic goals might serve as feasible first steps.

How can information of acceptable greenhouse-risks, and societal objectives of this kind, be translated to a company level? Azar and Rodhe [25] suggest that relative reduction targets on the same levels as for society at large may at least serve as a first approximation for the individual actor. Thus relative emission targets in society can be used as benchmarks also for smaller subsystems. In the office district of Nacka Strand, the European Union's goal of 8% is perhaps realistic within the time frame of this study.

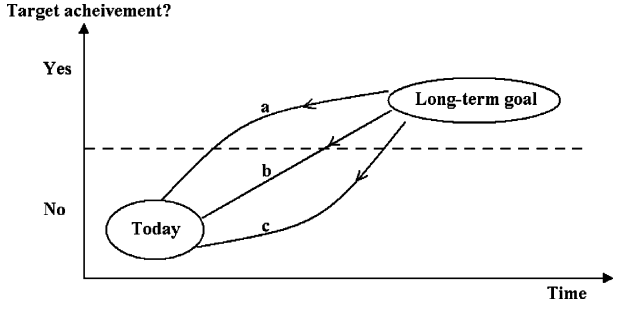

Fig. 1. The backcasting framework. The figure is adapted from Steen and Åkerman [24].

One way to reach a radical emission target would be to enforce drastic travel restrictions as company policies irrespective of the employees' attitudes. The other extreme would be to focus on how an improved work-atmosphere could be obtained, regardless of any objectives for CO_2 reductions. Still another extreme would be to launch very attractive objectives for CO_2 emissions as well as labour utility and disregard the costs. Essential in this research however, is to find solutions that reach the environmental goals in consistency with maintained or improved working conditions for the employees within given economic constraints for the employer even during the transition period.

2.2. Aspects influencing individual behaviour

Waldo [26], in her study on big city commuting, concludes that the most important measure to change individual travel habits is to increase the individual's accessibility to new, feasible, alternatives preferably in combination with incentives and information in order to stimulate the shift to their usage. In our backcasting framework, two questions were asked: (a) What aspects can be promoted from the company level in order to make the employees choose more efficient alternatives? (b) What is attainable if not only the company creates incentives and policies but also the society at large, e.g. by introducing green taxes, and policies to further stimulate companies to promote such initiatives?

Examples of aspects affecting employees' choices and travel behaviour can be grouped into the following three subcategories, where certain individual choices (i.e. the lowest level) may be dependent on higher hierarchies (i.e. the upper two levels), see Fig. 2.

2.3. Liberating the analysis from uncertain external factors

Radical long-term backcasting goals are probably not realistic to reach through changed attributes that arise solely within the company and individual domains. External factors such as green taxes or subsidies to sustainable initiatives might be needed to reach the target. The external factors, in the upper sub-category presented in Fig. 2 imply the most uncertain ingredients. They require decisions on the societal level that can occur only over relatively long periods. However, it might be relevant to separately analyse what is attainable without consideration of the future development of these uncertain external aspects, since what can be

External factors	• Local commuting services • Technical innovations • Green taxes • Laws and regulations • Public opinion • Subsidies for renewable fuel
Company policy measures	• Creating incentives to alternatives • Business trip policies • Promoting green fuel technologies • Telecommute arrangements
Individual choices	• Mode choice • Teleworking • Route choice • Rebound effects • Video/teleconference-substitution

Fig. 2. Hierarchical sub-grouping of examples of aspects affecting the employees' choices and travel behaviour.

achieved on the private domains can serve as role models for policy making on all levels of society.

So, from a backcasting perspective, short-term goals that are reached by role models in the private sector can be feasible cornerstones to societal long-term goals. To what extent is it possible to substitute vehicle miles in private cars and taxis solely from, e.g. modest price changes, new technological conveniences or other company-incentives? Inversely, what behavioural changes among employees might trigger new policy measures within companies, or what impacts can be achieved through new laws and political decisions in the society, supporting more sustainable travel alternatives?

The objective in this research is to study possibilities to reduce emissions from work-related travel, while at the same time maintaining or increasing the utility and sense of satisfaction of new technologies and life styles. To that end, it seems important to be as open as possible to all kinds of solutions and visions that may comply with this principle outcome.

3. Econometric forecasting

One example of a scientific framework that can be applied to model peoples' decisions in concrete choice situations is called *econometrics*. It is defined as "the application of mathematical statistics to economic data to lend empirical support to the models constructed by mathematical economics and to obtain numerical estimates" [27]. It is sometimes argued that econometrics has the limitation of only regarding money as a significant value. However, econometric modelling can be used to study many kinds of incentives for human behaviour, but the methodology does so by putting the incentives in relation to monetary terms. There are other weaknesses with this methodology, as in most methodologies aimed at the monitoring of human behaviour. Examples of mechanisms that may distort estimated behaviour from the real case are, for instance, over-estimating the importance of certain aspects, influence of group dynamics and group pressure that turn out to be more important in reality than what the individual would expect etc. Taking such uncertainties into account, and not over-interpreting data, econometric modelling offers a valuable method for ranking the importance of various aspects affecting human behaviour.

In order to estimate the *probability* for choosing between various alternatives one can assume that each individual strives for maximizing his/her *utility*, U, that can include all kinds of aspects that may influence the attractiveness of various alternatives and that are consequently studied in relation to each other. This is a common approach in econometrics when, for example, analysing people's preferences between different travel modes (see Refs. [28–30]).

The purpose of using econometric modelling in this study was to identify the conditions that would cause employees to change travel behaviour and to increase the use of transport modes that are more efficient with regard to money and natural resources. Let us assume a situation where company leaders wish to promote a biogas-driven carpool instead of taxi, for local business trips in order to reduce costs and emissions. In Fig. 3 below, the attributes a_i affect the willingness to switch towards a more efficient travel alternative (e.g. the carpool alternative)—the direction of the shaded arrows. Examples of such attributes influencing the choice are e.g. cost, travel time and convenience attributes such as efficient booking/payment systems, etc.

Changes of attributes affecting the utility and the emissions of the services might, in some cases, be dependent on external financing and support from the employer. Taking those institutional levels into account implies uncertainties. Examples of such aspects would be changes in company policies over long time frames, tax-reforms in favour of renewable fuel technologies, and policies and political reforms to create infrastructures for more convenient teleworking arrangements. However, also decisions on these levels should be

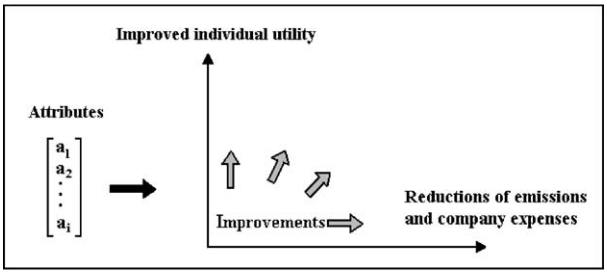

Fig. 3. Certain attributes (a_1–a_i) can lead to improvements both to the individual, the company and the society at large (increased utility, reduced trip-related emissions and reduced costs).

informed by knowledge on individual behaviour regarding the specific attributes.

In the example where the company leadership wants to investigate the willingness for their employees to choose carpool instead of the taxi for local business trips, we formulate the problem where the consumer (the employees) chooses between travel mode *carpool* and travel mode *taxi*. The aim from the modeller's perspective is now to derive the probability for choosing the carpool, where each of the two alternatives could be connected to some specific attributes. Each of the different attributes is tested as regards to the factors needed to influence behaviour (e.g. the carpool user could be compensated with X monetary units to increase the probability of choosing that alternative).

Furthermore, we could assume that these attributes correspond to a certain attractiveness or pleasure of using the two alternative services. In econometric modelling this is expressed as the individual's perceived utility. In this example we have the utilities U_{carpool} and U_{taxi}. The probability for choosing carpool instead of taxi could then be expressed as the probability that U_{carpool} is greater than U_{taxi}:

$$P(\text{carpool}) = P(U_{\text{carpool}} > U_{\text{taxi}}) \quad (1)$$

These utilities can be described as an additive linear function of the amount of different attributes x_i (e.g. cost) and the preference (or weight) parameters β_i:

$$U = \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k \quad (2)$$

Or in vector form: $U = \boldsymbol{\beta} \cdot X$, where $\boldsymbol{\beta}$ is the preference parameter-vector and $\boldsymbol{X}$ the attribute-vector, containing quantities of attributes such as the ones in Table 1 that affect the choice between the alternatives.

At the core of discrete choice analyses are various kinds of estimations of these preference parameters. The importance of each attribute in the individual's choice decision is revealed from the significance and the magnitude of the β-parameters corresponding to the specific attributes.

The β-parameters are indicators on what people favour most in the choice between alternatives (large positive values of β, e.g. comfort and monetary savings), what is of minor importance (β close to zero) and what is regarded as a disutility (negative values of β, e.g. costs, time loss, inconveniencies). By explicitly analysing the magnitudes of the β-parameters it is possible to trace the most decisive aspects in the choice between alternatives.

Table 1
Examples of attributes affecting the choice between the two alternatives, carpool and taxi

Alternatives	Carpool	Taxi
Attributes	Travel time	Travel time
	Travel cost	Travel cost
	GPS (yes/no)	Number of fellow-passengers
	Car type (electric/fuel)	Booking/payment system

The econometric forecasting procedure can be divided into two steps:

1. *Calibrate the β-parameters in the model*. To do this one can use a revealed preference or a stated preference survey from the population in focus. In our case of Nacka Strand, the models are calibrated by a stated preference survey [28]. This gives empirical data over the willingness to pay for a service or commodity that is not necessarily available on the market yet, and which the individual does not necessarily has an experience with at the time of the investigation.
2. *Forecast population market shares*. Once the values of the β-parameters are estimated over the population, large-scale forecasts can be carried out, predicting potential use rates and market shares of the services. If, for instance, the cost of carpooling is decreased while holding the cost for taxi use constant, the corresponding utility for carpooling will increase. This will result in a predicted increase of the probability for choosing carpooling instead of taxi, which could be converted into a potential shift in market shares between taxi and carpooling.

4. Behavioural modelling as a tool in the backcasting framework

Forecasting and backcasting are different approaches in the context of analysing complex systems. Forecast on the one hand means to make statements regarding the future, based on explicit or implicit assumptions from the present situation and observed trends. Backcasting on the other hand is a strategic problem-solving framework, searching the answer of *how* to reach specified outcomes in the future.

So far we have discussed the backcasting framework and the motives for using it in strategic planning to reach a long-term goal (Section 2). In that context the importance of classifying attributes having an impact on the individual's choice between alternatives, has also been discussed (Section 3).

This section describes the opportunities and limitations of using behavioural modelling from a company perspective. The objective is to use econometric modelling in order to assess how people behave in different situations. This information can serve as a pathfinder in the backcasting framework to reach long-term goals.

Let us assume a company leadership having a long-term image of the future, where the emission levels are

reduced to a certain acceptable level. As a central ingredient in this scenario, we assume that more efficient personal communication routines are essential. To fulfil this, the long-term development is dependent on numerous external factors that are not directly manageable solely within the company context (e.g. the political climate, the technological evolution and public opinions, see Fig. 2). However, regardless of the outcome of these factors there might be reason for not being passive and wait for changed external conditions. On the contrary, proactive company leaders may use backcasting to:

- Discover such measures that may optimise the probability for target fulfilment independently of future external factors (e.g. identify feasible measures for optimizing use rates of company-financed travel alternatives according to present conditions).
- Identify such measures that are most flexible with regard to future external factors.
- Identify such measures that may positively support other factors in the system, which may be utilized as future stepping-stones.

The potential users of the new alternative travel alternatives are key-players with regard to all three aspects. High use rates of the services favour the chances of reaching the objectives. In addition, the use rates of the services are a central part of the economical sensibility. Results from behavioural modelling facilitate the selection of those services in the scenario that are likely to promote progress towards the objectives.

To put this reasoning into the backcasting context, sketched in Fig. 1 in Section 2, the feasibility of each of the three backcasting paths (a, b and c) is highly dependent on the employees' behaviour and willingness to change their work-related travel.

To that end, we introduce an intermediate goal, the behavioural sub-goal. This sub-goal may be a necessary platform, needed to be able to launch subsequent changes (see Fig. 4).

In Fig. 4, this sub-goal is integrated into the backcasting framework. The paths leading from today to the behavioural sub-goal would consist of alternative ways to acceptable use rates of the services. Econometric modelling serves as a tool to find the most feasible path to the behavioural sub-goal, in consistency with individual utility. An example of a path would be the implementation of the most effective IT-attributes or other incentives, leading to a sufficiently high use rate of, e.g. carpooling and ride-matching. Another path would represent encouraging company policies and incentives leading to a more substantial adoption of videoconferencing and teleworking as substitutes for physical travel. The next step, when a sufficiently high use rate is achieved, is to find feasible paths between the behavioural goal and the long-term goal. Without sufficient use rates of the more efficient alternatives, further investments and long-term strategies are less likely to be realized, e.g. renewable fuels for vehicles, and political decisions to support implementation and maintenance of new services.

To use econometric modelling to identify and begin to evaluate some feasible paths in the backcasting framework is a deliberate way to analyse where money should be spent in development of the services. From the econometric modelling we may obtain some insight into getting an idea of which services and which attributes people favour. Also, we get the employees' willingness to pay for each of the services. The essence of the reasoning is that: *sub-optimisation in planning can be avoided*. The attractiveness of hypothetical investments can be tested theoretically before implementation. Investigating the willingness to pay among the users, as well as hypothetical use rates of the services, are useful guidelines for the companies sponsoring the efficient alternatives.

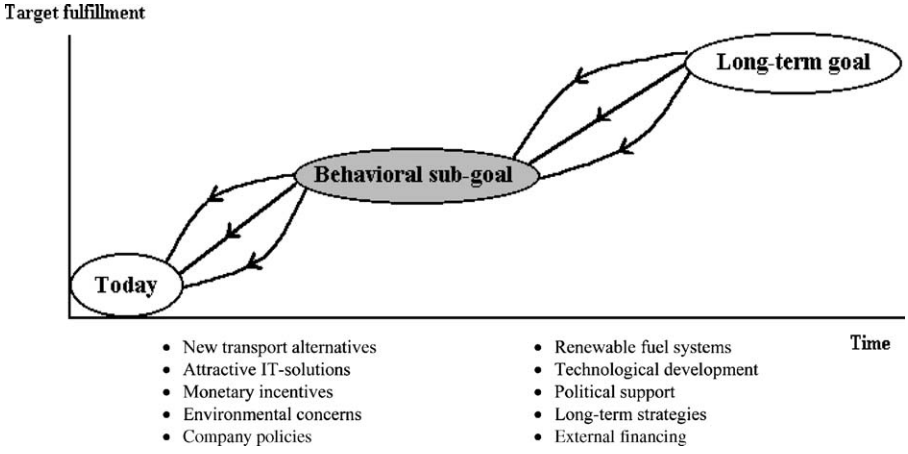

Fig. 4. To reach the long-term goal of reduced emissions and reduced costs, a behavioural sub-goal is implemented. The sub-goal can be reached by stimulating the use of new alternatives.

More effective political measures can be found. To reach sustainable long-term goals will need vigorous efforts from all three levels in Fig. 2. The econometric framework is of relevance when estimating various aspects that affect individual choices. With knowledge of these criteria more efficient economical frameworks in society to support sustainable development can be designed.

5. The IT-related services in the case of Nacka Strand

This section presents the office district in Nacka Strand, in which the empirical research takes place. The office area in Nacka Strand consists of 230,000 m^2, containing approximately 150 companies with 7000 employees [31]. The largest companies are the telecommunication companies Ericsson and Telia, having together approximately 2500 employees. There are 225 dwellings with 700 tenants. Alternative transport modes to the area are car, taxi, bus, bicycle and boat. The number of vehicles passing in and out of Nacka Strand is approximately 8000/week [32] (bicycles excluded) and the boat carries about 150 passengers per day on average [33]. As an alternative to private car and taxi, the office district also offers membership in a carpool, which consisted of 43 members in 2003 [34].

Ericsson and Telia, together with the landlord (AP fastigheter) have started a commuting project, in the current office district outside Stockholm, applying IT-technology as a logistic lubricant in order to stimulate the use of more resource-efficient transport alternatives. The motives are to improve the environmental profile, setting good examples of how IT is used efficiently in practice, to save money and time and to improve the working conditions for the employees.

Examples of IT-attributes that are implemented or planned for the services are efficient travel, booking and payment systems, traffic information in vehicles and information about scheduling and delays. The companies' long-term goal is to make the services more eco-efficient by switching to renewable fuels to improve the environmental conditions in the area. To make this realistic, the use rates of the services must rise drastically from the level of today. A challenge is therefore, to find the employees' criteria for considering these alternatives as substitutes for e.g. private car, taxi and aviation.

The concept relies on two fundamental ideas:

- *Communication does not necessarily have to imply physical travel.* In some situations (e.g. internal meetings, follow up meetings, etc.) the company and the employee may save money, time and resources by using telecommunications instead of physical travel.
- *Communication facilities do not have to be owned by the private user.* By ensuring that alternative communication services in the office district are available to all companies in the area, the companies share the expenses and of course the benefits together. In this way even the smaller companies can afford modern videoconference equipment and similar tools. The more companies joining the concept, the cheaper the services become on a per user basis.

5.1. Attributes tested in the stated preference survey

The employees' preferences for the different alternatives were tested in a stated preference survey. The aim of the survey was to determine the employee's perceived utility as dependent upon the attributes of the services. The specific attributes, assumed to have an impact on the attractiveness of the alternatives, were chosen after carrying out a focus group interview and a pilot study in the population.

One important aspect was to provide the employees with feedback information about the aggregate statistic results from the survey. This might give insight into the hypothetical effects from a macroscopic level (the whole company or the business district at large), stimulating more sustainable travel behaviour even on the individual level. The following five points were covered in the survey:

1. *Ride-matching system accessible on the web.* This is a hypothetical scenario, where we test for the willingness to pick up colleagues on local business trips and on commuting trips. The idea is that employees in Nacka Strand have access to a map on the web, where they fill in their route to work. A computerized matching system helps people having similar routes come in contact to share a car to work. We tested the monetary compensation necessary to make drivers willing to pick up passengers on commuting trips and local business trips. The system could consist of:
   - A ride-matching system accessible on the web, and
   - A mechanism for car drivers to pick up colleagues as passengers on work-related car trips.
   - A compensation system to make it worthwhile for the drivers to do so.
2. *Using a carpool instead of a taxi for local business trips.* There are a few dominating business districts in the Stockholm region, to which local business trips from Nacka Strand frequently occur. As a measure to decrease the cost and pollution from single passenger taxi trips, a carpool facility is accessible in the area. Here we tested the willingness to choose carpool instead of taxi for these trips, if the user gets a share of the company's monetary saving. We also tested the following attributes that might affect the choice:
   - GPS-navigation system in the carpool; and

- the interest for an electric vehicle or a more exclusive type of car, instead of the present ordinary car; and
- a compensation system to make it worthwhile for choosing carpool.

3. *Testing the commuting boat with and without IT-services*. This stated preference survey allowed us to analyse the impact from specific IT-services and other improvements, having the potential to increase the attractiveness of new travel alternatives:
   - Messages via SMS-service to the mobile telephone, in case of divergence from timetable; and
   - GPS-positioning services accessible on the web so that the passengers can minimize outdoor waiting times and get information on possible delays.
4. *Teleworking, including office space reductions*. By organizing the staff into part-time teleworking arrangements, the company has the opportunity to reduce office space needs and consequently to reduce rental costs. Have such reductions been done anywhere and if so have the cost benefits been ascertained? The idea is to let several employees use the same office space, but on different days. As compensation, the employee gets a part of the company's monetary saving. This arrangement might include some inconveniences in the daily work. In this stated preference survey we tested for the least monetary compensation necessary to make employees accept:
   - Open-plan office instead of stationary office room.
   - Foldaway desktops instead of stationary desktops.
   - Monetary compensation for accepting flexible office.
5. *Other information collected in the survey*. In addition to the stated preference surveys we also include background questions in the survey. This includes questions focusing on:
   - Potential substitution rates of long-distance business travel for IT-facilities such as video- and teleconferencing.
   - General attitudes towards IT as a substitute for physical travel.
   - Background information about the family and home work situation.
   - Daily work-commute patterns.
   - Local business trip patterns.
   - Attitudes towards teleworking.
   - Socio-economic variables.

5.2. Three practical backcasting examples

One can think of several examples where integrating econometric modelling as a complement in a backcasting framework is relevant. This section presents three concrete examples in Nacka Strand.

5.2.1. Carpool and ferry

Long-term backcasting goal: to turn the carpool or the boat into sustainable transport alternatives for work-related travel by investing in renewable fuel technology. In order to make the investment economically defensible the use rate of the services must increase drastically from the level of today.

Behavioural analysis: is there a potential for both the carpool and the boat to reach the long-term goal, or should either of the two be prioritised? The forecasting task is to predict the conditions that make it possible to increase the probability for use of the two services, i.e. what attributes would make the services more attractive to the employees? For example, what would the corresponding market share for carpool instead of taxi be if the employees obtained part of the companies' savings from travel expenses? Accordingly, would an investment on a real-time positioning system on the boat increase the reliability of the boat and increase the willingness to pay for the service? Of course one outcome might be that none of the attributes tested might increase the use rate to a sufficient level to finance renewable fuel technology. In that case other services or attributes might be more relevant to consider.

Company's backcasting path: with insight into what the employees favour the most in the choice of boat and carpool, it is possible to optimise the use of either of the two services. Depending on the findings over which attributes are important, the most appropriate investments can be made and sub-optimisations avoided. A high use rate is of crucial importance if considering introduction of renewable fuel systems. It implies both a larger environmental impact as well as a more economically defensible investment.

5.2.2. Ride-matching

Long-term backcasting goal: the number of drive-alone trips at work-commute and local business trips is reduced to a certain extent as a result of a successful launch of a ride-matching system between the companies in Nacka Strand. Expenses as well as emissions are reduced from the employees' work-commute and companies save expenses from reduced travel subsidies, number of parking lots and improved public relations (PR).

Behavioural analysis: the first step is to predict the conditions that influence car drivers' willingness to pick up passengers in their cars. An example is to find the monetary incentive necessary to make drivers willing to accept the inconvenience. Other attributes that are possible to test are, e.g., the possibility of driving in bus-lanes, time spent in the car, the number of passengers and type of passengers (e.g. does it matter if the passenger is a colleague from the same company as the driver or not). If the least necessary compensation is unreasonably high, the feasibility of the long-term goal can be questioned—at least on the premise of voluntary car drivers.

Company's backcasting path: with knowledge of the drivers' criteria for driving colleagues in their cars, the companies can focus on how to arrange the system to work in practice. A web-based ride-matching system might facilitate the coordination between drivers and passengers. In the end, perhaps more far-reaching investments might be thinkable, such as company-financed ride-matching cars.

5.2.3. Flexible working places

Long-term backcasting goal: company expenses to the landlord have reduced drastically from a new flexible workplace arrangement. Instead of fixed, private office rooms, the employees share the same office space but at different occasions. Instead of ordinary desktops with stationary computers and drawers, the employees use foldaway desktops and laptops. Some criteria fulfilled are e.g. that employees are willing to adopt this new work form and that the level of teleworking has increased substantially. As a secondary result, environmental improvements are seen from less use of heating and electricity in office buildings and from employees' reduced work-commute.

Behavioural analysis: how much do the employees value their office rooms? An example is to identify practical inconveniences related to the new work form. A measure of the inconvenience of the changed workplace is to study the minimum monetary compensation that would compensate the employees in order to make them willing to give up their office rooms. A rationale for this would be that part of the company's reduced expenses went to the employees. Of course one outcome would be that the employees' least necessary monetary compensation is too large to make the whole idea profitable.

Company's backcasting path: with information on the employees' least necessary compensation to give up their office rooms, the company can strategically plan for other criteria essential to make the long-term goal achievable. For instance introduce incentives and policies stimulating teleworking and extend the concept to include even other office facilities outside Nacka Strand so that long-distance commuters living closer to Nacka Strand can use the flexible work facilities as well.

6. Conclusions

IT has a great potential to save resources, and has therefore a place in the discussion about sustainable development. Experience from the early days of IT shows that there is no evident correlation between the use of IT and a lower demand of natural resources. The potential of saving resources must be separated from the actual result. This makes it interesting to study the conditions for a *deliberate* use of IT to lower the environmental pressure. The philosophy is to create win–win situations, where the individual, the organization, the society at large, and the environment all become winners. This makes behavioural modelling and econometrics automatically to a field of great potential in the search for tools and strategies, since it describes the individual's incentives in the choice of feasible alternatives.

To that end, this study has elaborated a framework for planning, built on backcasting from combined objectives of emission targets, monetary savings and individual utility. In this context, the motive for integrating the econometric toolkit to model behaviour is presented. The latter is applied to study and foresee individual behaviour, so that conditions that can promote the reaching of overall objectives from an individual point of view can be detected and sub-optimised measures and blind alleys of planning can be avoided.

The framework will be applied in a field-study—The Nacka Strand project. This study has the potential to test:

- The applicability of the suggested framework for studying and modelling resource saving behaviour on the individual level.
- How a relatively large diversity of new and less resource consuming transport services work as substitutes in practice.
- The role of companies and the potential to utilize active policy making to create win–win solutions from the objectives in the framework.

One aspect that may also be interesting to study goes beyond rational decision-making and relate to the well-known dilemma "old habits die hard". The power of habit may positively favour old and well-tried alternatives on behalf of new ones. One can think of situations where a comparison between the attribute-lists of two alternatives would give rational arguments to substitute the old alternative for the new untried one—and still the old one may remain. In that situation the role of information and promotion fills a certain meaning in order to break the barrier of the first attempt. IT may for instance increase the applicability of information and IT can improve the quality of information by making it closer to the new reality, for instance through videos on web sites and other virtual means. A great effort must be put on integrating the services in the company structures for information including advertisement, newsletters, and promotion through diverse incentives.

References

[1] Arnfalk P. Information technology in pollution prevention. Licentiate dissertation. The International Institute for Industrial Environmental Economics, Lund University; 1999.
[2] Robèrt M. Möjligheter att spara energi genom ny teknik—exempel från Ericsson. Master of Science thesis, KTH, Stockholm; 2000.

[3] Golob TF. Travel Behavior.com: activity approaches to modelling the effects of information technology on personal travel behaviour. Presented at IATBR 2000, the Ninth Conference of the International Association for Travel Behaviour Research, Australia; 2–7 July 2000.
[4] Golob TF. Impacts from information technology on personal travel and commercial vehicle operations: research challenges and opportunities. Transport Res Part C 2001;9.
[5] Wiener N. The human use of human beings: cybernetics and society. Boston, Mass: Houghton Mifflin; 1954.
[6] Graham S, Marvin S. Telecommunications and the city: electronic spaces, urban places. London: Routledge; 1996.
[7] Taylor S, Button K. The complex nature of interactions. Institute of Transport Studies, Monash University. School of Public Policy, George Mason University; 2001.
[8] Denstadli JM, Julsrud TE, Jakobsen MH. Video mediated communication—a new meeting place for business? Institute of Transport Economics, Telenor Research and Development, Oslo; 2001.
[9] Salomon I, Schofer JL. Forecasting telecommunications–travel interactions: the transportation manager's perspective. Transport Res A 1988;22.
[10] Johansson A. Kommunikationsmönster hos befolkningen—Resultat från SIKA:s kommunikationsundersökningar. SIKA Rapport 2001;6.
[11] Mokhtarian PL, Salomon I. Modelling the choice of telecommuting: identifying the choice set and estimating binary choice models for technology-based alternatives. Environ Planning A 1996;28.
[12] Balepur P, Varma K, Mokhtarian PL. The transportation impacts of center-based telecommuting: interim findings from the neighbourhood telecenter's project. Transportation 1998;25(3): 287–306.
[13] Zumkeller. The impact of telecommunication and transport on spatial behaviour. Institute For Transport Studies, Karlsruhe. Survey of 4500 households in Bavaria, Baden-Wurttemberg, Seoul and Sweden; 2000.
[14] Mokhtarian P. An empirical evaluation of the travel impacts of teleconferencing. Transport Res A 1988;22.
[15] Handy SL, Mokhtarian PL. Forecasting telecommuting: an exploration of methodologies and research needs. Transportation 1996;23.
[16] Mokhtarian PL, Salomon I, Saxena S, Sampath P, Cheung K, Le K, et al. Adoption of telecommuting in two California State Agencies UCTC No. 338; 1996.
[17] Mokhtarian PL, Krishna VV. The trade-off between trips and distance travelled in analyzing the emissions impacts of center-based telecommuting. Elsevier Science Ltd.; 1998.
[18] Toffler A, Toffler H. Creating a new civilization: the politics of the third wave. 1st ed. Atlanta: Turner; 1995.
[19] Grübler A. The rise and fall of infrastructures: dynamics of evolution and technological change in transport. Heidelberg: Physica Verlag; 1989.
[20] Höjer M, Mattsson L-G. Determinism and backcasting in future studies. Futures 2000;32.
[21] Robinson. Energy backcasting: a proposed method of policy analysis, Energy Policy, Robinson credits the idea to Amory Lovins; 1982.
[22] Dreborg K-H. Essence of backcasting. Futures 1996;28(9).
[23] Åkerman J, Dreborg K-H, Henriksson G, Hunhammar S, Höjer M, Jonsson D, et al. Destination framtiden—Vägar mot ett bärkraftigt transportsystem. KFB-Rapport 2000;6.
[24] Steen P, Åkerman J (1994) Syntes av studier över omställning av energi- och transportsystemen i Sverige. A report from the Swedish Governmental Committee on Climate. SOU; 1994. p. 138.
[25] Azar, Rodhe. Targets for stabilization of atmospheric CO_2. Science 1997;276:1818–9.
[26] Waldo Å. Staden och resandet-mötet mellan planering och vardagsliv, sociologiska institutionen (doktorsavhandling), Lunds Universitet; 2003 [in Swedish].
[27] Samuelsson PA, Koopmans TC, Stone JRN. Report of the evaluative committee for Econometrica. Econometrica 1954;22.
[28] Louviere JJ, Hensher DA, Swait JD. Stated choice methods: Cambridge University Press; 2000.
[29] Thomas RL. Modern econometrics—an introduction: Addison Wesley Longman; 1997.
[30] Greene WH. Econometric analysis. Prentice-Hall, Inc; 2000.
[31] Lennart Berg, regional manager at the landlord AP-fastigheter.
[32] Swedish National Road Administration; October 2000.
[33] Stefan Hagbard, project leader for the boat transport, personal communication; 2001.
[34] Lennart Ljung, head of carpool operation at Statoil, personal communication; 2001.