Climate and traffic : prospects for Finland

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Abstract

The paper contributes a 'soft' way of making scenarios for climate policy that takes into account the diverse views of various interest groups. A two-rounded Delphi method is used to produce scenarios for a transport CO_2 policy for Finland. Quantitative statements of the interest groups are run with cluster analysis and qualitative arguments for the statements are attached to the clusters. The resulting six clusters are interpreted in the light of theoretical strategic scenarios of transport and environment, which take different positions on dematerialisation and immaterialisation. Although one could observe only little dematerialisation and no immaterialisation in the relationships between GDP, road traffic volume and CO_2 emissions from road traffic in Finland from 1970–1996, all of the clusters anticipate dematerialisation and five, immaterialisation during 1997–2025. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Climate policy; Cluster analysis; Delphi method; Environmental policy; Scenario; Transport

1. Introduction

Global climate policy is facing a problem of increasing carbon dioxide (CO_2) emissions from transport; especially from road and air transport. The CO_2 emissions from transport followed the increasing traffic volumes between 1986 and 1995 in the current European Union (EU15) countries as well as in the United States and Japan, in spite of technological development. People have been buying bigger cars and the number of passengers in vehicles has decreased due to increased income and individual life-style. The market share of road freight transport has also increased as smaller units are delivered 'just-in-time'. (IPCC, 1996, p. 690; ECMT ref. Lampinen, 1998, p. 9; Eurostat, 1999, p. 10, 38, 56, 81; Tapio, 2000a, pp. 6–7; IEA, 2000, pp. 15–27.)

The linear growth of global motorisation from 1976 to 1996 can be seen in Fig. 1. The figure indicates that the increase in the total automobile stock may have begun to level off in North America and Europe whereas the highest growth rate of the 1990s can be found in

Asia. Despite the high growth rates of population in Africa, there is so far no sign of following the high mobility of the more industrialised world in absolute terms.

Fig. 2 illustrates that in the EU15 countries the CO_2 emissions from traffic have been clearly increasing between 1985 and 1996, whereas other sectors of production and consumption have been able to maintain the CO_2 emission level of 1985 or even go below it. Thus, more attention to transport related problems should be addressed in climate policy.

1.1. On the methods of futures studies

The future prospects of transport are usually studied using mathematical models to make conjectures about the probable future development. A common starting point of the models is normally a 'business-as-usual' growth projection of gross domestic product (GDP), which will result in increased income of households which in turn will affect car ownership and car use. Increased GDP is typically assumed to largely consist of industrial output and to result in respective growth in freight transport volume. When a 'business-as-usual' population forecast and a certain percentage in im-

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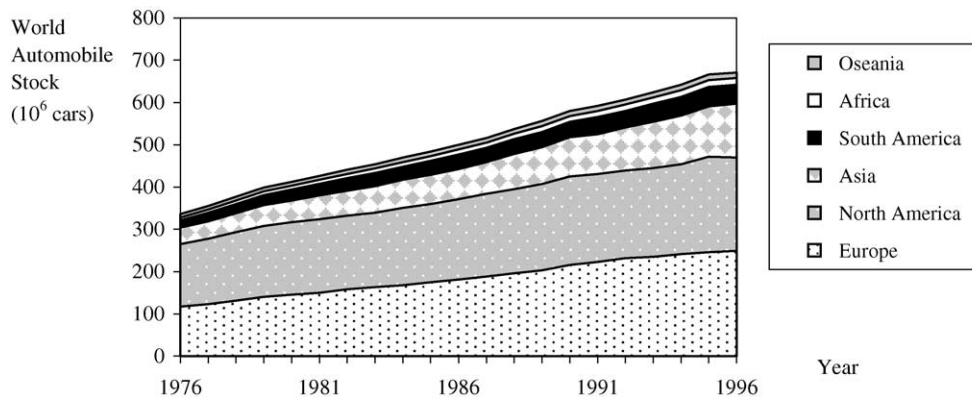*E-mail address:* petri.tapio@tukkk.fi (P. Tapio).

Fig. 1. Total automobile stock in world areas from 1976 to 1996, including light and heavy duty passenger cars, buses, vans and lorries (Ministry of Transport, 1999a, appendix p. 38).
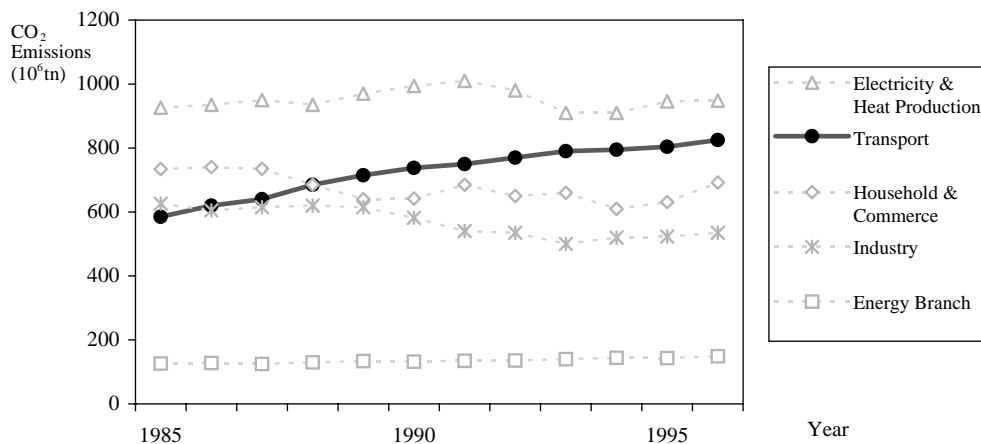

Fig. 2. CO_2 emissions from fossil fuels by sector in the EU15 countries from 1985 to 1996 (Eurostat, 1999, p. 81; Eurostat, 2000).

provement of fuel efficiency is assumed, if any, the chain from the economy back to the CO_2 emissions of traffic is complete.[1] (Kokkarinen, 1991; IPCC, 1996, pp. 683–691; see also Cohen et al., 1998; Banister, 1998.)

The straightforward argument of the 'business-as-usual' mathematical models has proved to be correct in the past, although the assumptions concerning the GDP or population have sometimes proved to be incorrect (Kokkarinen, 1991; IPCC, 1996, pp. 683–686; Button, 1996, pp. 12–13, 18–19). The problem is that if one seeks to find paths of change in the future, this leaves little room for different policy options or change in human behaviour and life-style. When used in decision-making the forecasts tend to have a self-fulfilling nature (Button,

1996, p. 205; Tapio, 1996; Cohen et al., 1998). In fact, there are indications that high-growth predictions have been used as marketing tools for large traffic infrastructure projects (Tapio, 1996; Skamris and Flyvbjerg, 1997).

A more sophisticated and policy-oriented way of studying the future is the so-called 'what if' models, where the analyst imports factors to the model that are internal to decision-making and constructs alternative future scenarios by varying them. The factors may include fuel prices, car prices, number and location of parking places, speed limits, urban structure etc. (e.g. Acutt and Dodgson, 1998, pp. 40–42; Chiquetto and Blackledge, 1999; Bouwman, 2000, pp. 48–61; OECD, 1997). Also 'soft' attitude and life-style factors are sometimes included in the 'what if' models as stated preferences or revealed preferences (e.g. Sasaki et al., 1999; Arentze et al., 1999). Even if the 'soft' factors were included, there is no guarantee that the models would be used following the 'what if' principle. (Schwarz et al., 1982, pp. 40–42; Tapio, 1996; Steg et al., 1997, p. 195.)

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[1] The national forecasts have different assumptions of the saturation level of passenger car density, that may vary from 500 to 750 private cars per 1000 inhabitants. The assumed income and price elasticities also make a difference in the shorter run. (Kokkarinen, 1991.) The elasticities are less important in the long run, say 30–50 years, because the grand theory of the models is that ultimately there will be a situation where virtually all adults own and use private cars.

A third approach to study future prospects is to ask people of their images of the future. The people can consist of a panel of experts as well as of interest groups or individual citizens. Participatory planning procedures are included in this category as well as opinion polls and thematic interviews about the images of the future. Another example is the Delphi method, which is applied in this study. Some attitude surveys of opinions on transport policy have been conducted (e.g. Socialdata, 1992, pp. 23–25), but empirical analysis of the perceptions of interest groups seems not to have been done (Tengström, 1999, p. 194).

The Delphi method is traditionally used to gather expert opinions of the most probable future but it has also been used to examine the differences and similarities of the views on the preferable future. It enables less rigorous scrutiny than 'business-as-usual' models and the 'what if' models but it is open to various factors affecting the future and open to arguments for change. (Linstone and Turoff, 1975; Ziglio, 1996; Kuusi, 1999.)

Delphi has not often been applied in the transport field (Gupta and Clarke, 1996; Still et al., 1999). In their Delphi bibliography Gupta and Clarke reported over 600 Delphi publications of which only eight included transport in their titles. The author is aware of only one Delphi report on the subject of the relationship between economic growth, transport volumes and CO_2 emissions from transport (Karmasin and Karmasin, 1999).

1.2. Focus of the article

The purpose of this article is to analyse interest group views on the future of the economy, transport and CO_2 emissions on a national level in Finland. What views are presented of the probable and preferable futures of the GDP, road traffic volume and the CO_2 emissions from road traffic in Finland for 1997–2025? The three

variables were chosen because they correlated strongly from the late 1970s to 1996 and made a suitable starting point for the analysis (Fig. 3). To view the variables connected or de-coupled in the future implies theoretical positions of dematerialisation and immaterialisation. The quantities presented imply grades of growth optimism versus growth pessimism.

A separation of road traffic volume and road traffic CO_2 emissions would be an example of dematerialisation. The decoupling of GDP and road traffic volume would be an example of immaterialisation. Despite all the development in vehicle technology and the discussion of non-material economic growth, post-industrialism, decoupling and decarbonisation (e.g. Baum, 1995; Goodwin, 1995; Banister, 1998, pp. 1–2; Tengström, 1999, pp. 205–207; Hinterberger and Schmidt-Bleek, 1999), little if any empirical evidence of these phenomena could be established in Finnish transport from the late 1970s to 1996.

But what will the future look like according to the interest groups? An application of the Delphi method was used to produce and analyse the data. The answers were interpreted with reference to theoretical strategic scenarios of environmental policy, which take different positions on dematerialisation and immaterialisation as well as growth optimism and growth pessimism. A more general Delphi study on Finnish climate policy has been made by Wilenius and Tirkkonen (1997).

2. Material and methods

2.1. Disaggregative Delphi

The idea of the traditional Delphi method is to compile the views of an expert panel about the probable future on a topic that has many interpretations and is
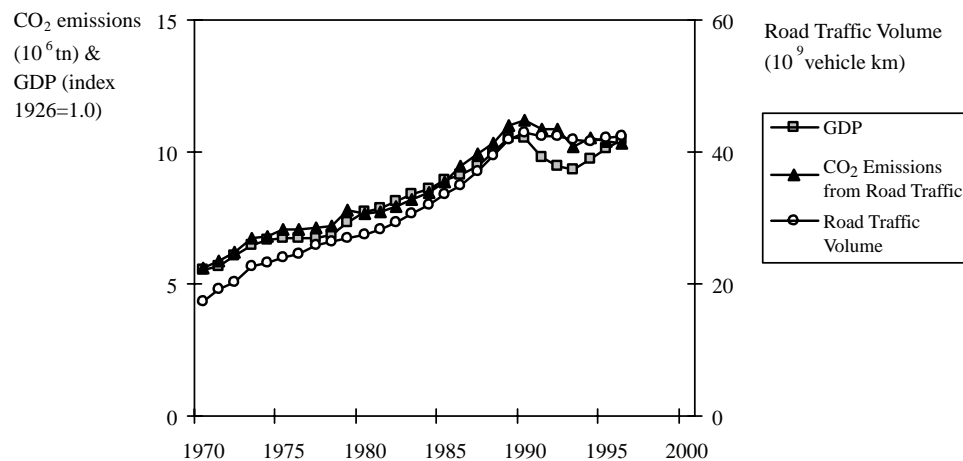

Fig. 3. The volume and CO_2 emissions of road traffic, and the GDP in market exchange rates and in real terms of Finland from 1970 to 1996 (Mäkelä, 1997; FinnRA, 1997; Statistics Finland, 1997).

hard to formalise in mathematical models. It may also be used when there is insufficient data on the topic or when changes in the relations between variables are intuitively expected. (Linstone and Turoff, 1975, p. 4; Ziglio, 1996, pp. 3–4; Rotondi and Gustafson, 1996, pp. 39–40.) As noted above in the lively discussion of dematerialisation and immaterialisation, a change in the relations between the three key variables is widely expected and desired.

The Delphi method consists of at least two rounds (sometimes as many as five); the purpose of the rounds is to ask the experts to construct arguments for and against some future issues. The argumentative rounds are usually anonymous, so that the status or background organisation of the experts would not affect participants' opinions. The idea of the traditional Delphi is to reach a consensus among the panellists. (Linstone and Turoff, 1975; Ziglio, 1996, pp. 3–6.)

In this study the Delphi method was used in a somewhat unusual way (see also Tapio, 2000b). The panel participants were from 14 interest groups that wish to influence transport and environmental policy in Finland: these included transport and environmental administrators, environmental movements, lobbying groups for different traffic modes, industry and a transport workers' trade union (Table 1). The widest scope of diverse views were gathered in order to get estimates of the 'weak signals' of the future. Therefore, conservative as well as radical groups were invited to the process.

The sample of organisations was a little biased in two ways: First, air transport and water transport interest groups were not included. This was not a problem because for geographic reasons air and water transport are not serious competitors of road traffic in Finland. Second, two important groups dropped out during the study, namely the Ministry of Treasury and the car importers. The Ministry of Treasury plays a crucial role in forming the budget of transport infrastructure construction and transport taxation. Car importers might have added insight into the technical development of vehicles. Only the car users' interest group was represented. Also one environmental NGO dropped out, explaining that its view would probably be similar to that of the Traffic League (see Table 1).

The participating organisations nominated their own representatives. In some cases these were the operative managers, in others their subordinates. Some organisations had only one representative, others had two.

Some applications of the Delphi method have been critised for ignoring and not exploring disagreements (Linstone and Turoff, 1975, p. 6; Schwarz et al., 1982,

Table 1
The respondent organisations of the study and their respective acronyms

Acronym	Finnish name	English name or author's translation in italic
Lobbying groups of different transport modes		
AL	Autoliitto	Automobile and Touring Club of Finland (passenger car users)
LILI	Liikenneliitto	Traffic League (surface public transport)
LAL	Linja-autoliitto	*Bus Transport Federation (buses)*
STY	Suomen tieyhdistys	Finnish Road Association (road construction)
ENE	Enemmistö	*Traffic Policy Association Majority (bicycle, pedestrians)*
Transport administration		
LM	Liikenneministeriö	Ministry of Transport and Communications
RHK	Ratahallintokeskus	Finnish Rail Administration
TL	Tielaitos	Finnish Road Administration
YTV[a]	Pääkaupunkiseudun yhteistyö-valtuuskunta/ liikenneosasto	Helsinki Metropolitan Area Council/ Transportation Department
Other groups with economic interest		
AKT	Auto-ja kuljetusalan keskusliitto	*Transport Workers' Federation*
TT	Teollisuus ja työnantajat	The Confederation of Finnish Industry and Employers
ÖKKL[a,b]	Öljy- ja kaasualan keskusliitto	Finnish Oil and Gas Federation
Environmental administration		
YM	Ympäristöministeriö	Ministry of the Environment
Environmental non-governmental organisation		
DODO	Dodo-Tulevaisuuden elävä luonto	*Dodo-The Living Nature of the Future*

[a] Responses from YTV and ÖKKL are operative managers' own views, not the organisations'. The YTV response is hence marked by the acronym YTV* elsewhere in the text.
[b] ÖKKL did not produce quantifiable answers of probable and preferable futures but responded by qualitative aspects of possible future developments. Therefore, ÖKKL is not included in the cluster calculations.

p. 13). In this study, a goal of consensus between the participants was not adopted. Instead, a set of alternative long-term traffic and environmental policy scenarios was produced.

In the first Delphi round, research material was gathered using a questionnaire. The questionnaire included a graph showing the development of GDP, road traffic volume and CO_2 emissions from road traffic from 1970 to 1996 in Finland (see Fig. 3). The panellists were asked to draw graphs showing the most probable and most preferable future trends and to give their views on why and how their image of future would be realised.

During the second Delphi round the panellists were interviewed after receiving a feedback report from the first round. All the answers from the first round were presented anonymously in graphic form, variable by variable. The arguments from the first round were grouped into three categories: represented by the upper curves, middle curves and lower curves on the graphs. The interview included quantifiable questions, multiple-choice questions and open questions. The role of the researcher was to pose contra-arguments in order to get more in-depth arguments from the respondents (see "Argument Delphi" in Kuusi, 1999, pp. 128–134). This type of active role is different from the usual neutral or sympathetic interview strategies and is sensitive to bias. However, it was considered applicable because the respondents had a routine to participate in debates and to be interviewed by journalists. The argumentative method was explained to the interviewees in the beginning in order to ameliorate the feeling of conflict. The arguments were presented as somebody else's views by expressions as "there has also been a suggestion that…", "what do you say to the argument that…?" etc.

2.2. Cluster analysis

Usually the results of Delphi studies are reported in terms of median and quartiles, sometimes also in extreme deciles. Reduction of deviation during the rounds is normally considered a success (e.g. Rotondi and Gustafson, 1996, p. 35; Still et al., 1999, pp. 85–86). As the goal of consensus was not adopted in this study, the answers of the three key variables, GDP, road traffic volume and the CO_2 emissions from road traffic were grouped in a disaggregated way. The grouping was made by the cluster analysis provided in the SPSS 8.0 software. Clustering methods do not require random sampling if they are not used to verify a theory, because they can be used only as tools to group similar cases together (Dubes and Jain, 1979; Milligan, 1998, p. 122). Cluster analysis is rarely used in Delphi studies but has been recommended by Turoff and Hiltz (1996, p. 72).

The furthest neighbour (i.e. complete linkage) clustering method was used. Both the preferable and probable responses were analysed simultaneously. Because two respondents did not produce quantifiable answers to all three variables, the number of cases totalled 24. The simple Euclidean distance was chosen for the measure of association. The 1996 values of GDP and CO_2 emissions happened to be almost identical (10.5 and 10.3) and the numerical value of road traffic volume was four times greater (42.5). If the three variables were considered equally important, they should have been standardised by an index number. However, no variable standardisation was conducted. Road traffic volume was considered most important of the variables, because the purpose of the study was to build transport scenarios. Since the CO_2 and GDP numbers were so close to each other, standardisation was not considered necessary. The cluster centers were calculated by measuring the arithmetic means of the variable values within a cluster. (See Tapio, 2000b.)

The qualitative arguments given by the respondents were attached to the quantitative clusters. The interviews were transcribed and the arguments gathered. The common plot of the arguments and possible discrepancies between the arguments were analysed.

Researchers using the Delphi method have been criticised for the lack of theoretical interpretation of the results (Bell, 1997, p. 270). In order to avoid this pitfall, the produced clusters were compared with the theoretical strategic scenarios of environmental policy presented in the next section. Comparison is made in the results section. Some restrictions of the method will be presented in the discussion section.

3. Theoretical strategic scenarios of transport and environment

In this section, five theoretical strategic scenarios applied to transport and CO_2 policy are presented:

- 'Business-as-Usual' (BAU)
- Economic and Technological Optimism (ETO)
- Ecological Modernisation (EMO)
- Structural Change (SC)
- Deep Ecology (DE)

The typology is constructed from the works of Næss (1976, pp. 16–20, 99–115), Jänicke (1988, pp. 14–16), Massa, 1995, p. 14, Sairinen (1996, pp. 28–38), Wilenius and Tirkkonen (1997), Baker et al. (1997, pp. 8–18) and Kaivo-oja (1999), and describes the possible strategies in environmental policy. The different strategies have different positions concerning dematerialisation and immaterialisation. They also imply differences in growth optimism and growth pessimism and therefore aspects of them can be traced back to the Limits of Growth debate between neomalthusian and

cornucopian approaches (e.g. Dunlap, 1983). For a more detailed presentation, see Tapio (2000a).

'Business-as-Usual' (BAU) describes the reference scenario, where little or no adjustment to past policies is made. It is close to a combination of remediation and end-of-pipe policies by Jänicke and Sairinen. The economy would grow steadily and there would be only minor stagnation of the road traffic volume and only small improvement in fuel efficiency. The rest of the scenarios are supposed to fulfil or go beyond the CO_2 emission target of the Kyoto Protocol (1997) which for Finland is maintaining the 1990 emission level to 2010, in general as well as in road transport (Ministry of Transport, 1999b).

Economic and Technological Optimism (ETO) is similar to Næss' shallow ecology, the boomsday scenario by Kaivo-oja, the preventive environmental policy by Sairinen and the treadmill approach by Baker et al. Also the narrow technology oriented interpretation of ecological modernisation is close to this scenario (see Huber, 1995; Jokinen, 1995; Mol, 1996). The main idea of the ETO scenario is that the environmental problems can and should be solved or at least sufficiently mitigated by technical development. No change in human action is required. The economy and road traffic would grow faster than in the BAU scenario, but the CO_2 emissions could be reduced slightly from the level of the 1990s.

Ecological Modernisation (EMO) is similar to Jänicke's. The concept of weak sustainable development by Baker et al. is also similar. The main idea of EMO is that, not only technology is improved, but also some change in human values and action and societal institutions is expected. Reduction of environmental impacts is the main focus in the development of technology in the EMO scenario whereas in the ETO scenario the normal techno-economic efficiency principle is also assumed to produce ecologically sustainable technology. The economy would grow at a similar rate to the BAU scenario, but road traffic volume would increase less and the CO_2 emissions would reverse to a slow decrease from the level of the 1990s.

The Structural Change (SC) scenario is similar to Jänicke's as well as Wilenius' and Tirkkonen's idea of structural change. It is also close to the concept of strong sustainable development, presented by Baker et al. and Kaivo-oja. In the SC scenario the emphasis is on structural changes of production and consumption patterns. The scope of it is more human oriented than that of the more technically oriented scenarios above. Although the economy would grow at a similar rate to the BAU scenario, road traffic volume as an indicator of material growth would stop growing altogether and the CO_2 emissions would decrease clearly from the level of the 1990s.

Deep Ecology (DE) is adopted in the spirit of Næss and Kaivo-oja. Also the ideal model of Baker et al. has similar qualities. The DE scenario is the most radical scenario requiring reduction of material consumption in industrial countries. Improving technology and structural changes in production and consumption patterns is not seen to be enough. Thus, the growth of the economy would be stopped and road traffic volume would decrease clearly from the level of the 1990s to reduce the CO_2 emissions by at least half.

The theoretical scenarios are qualitative at heart, but in order to make the interpretation of the results more explicit, they should be operationalised into quantifiable terms. The slide from qualitative to quantitative seems to be an unorthodox act in the humanistic sciences while presenting a "quasi exact" approach (e.g. von Wright, 1986, p. 112), but it can also be regarded simply as a more precise formulation of the theories. The actual quantities were generated manually by the author before the cluster analysis; no mathematical models were used (see Figs. 4–8). This in turn seems unorthodox in the quantitative scenario school of thought, which might consider the slide overly subjective or even arbitrary.

The normal quantitative approach is to form a mathematical model and make input presumptions of the development of the explanatory factors and leave the output to the model. When considering future events, these input presumptions are subjective and questionable. Formal calculations cannot transform the subjective input into objective output. Thus the lack of a formal model does not make the quantification here any more subjective than what future scenarios always are. It is important to remember that direction and relations between the variables are more important than the exact figures.

4. Results of the disaggregative Delphi study

This section presents the results of the respondents' views from the second Delphi round about probable and preferable futures of the GDP, the road traffic volume, and the CO_2 emissions from road traffic in Finland from 1997 to 2025. The quantitative clusters are complemented with the respondents' qualitative arguments.

The hierarchical cluster analysis gave a well argued choice between three, four, six and ten clusters—four and six being the most apparent ones. Cluster analysis does not ultimately make the decision regarding the number of clusters; instead certain criteria can be used to eliminate the less relevant options. Because the purpose was to produce alternative strategic scenarios based on the clusters, the chosen number should take into account the requirements of decision-making. Two scenarios would probably give the feeling of right and wrong alternatives. When three scenarios are formed the decision maker might tend to choose the middle one. There are also limits to understandable alternatives and
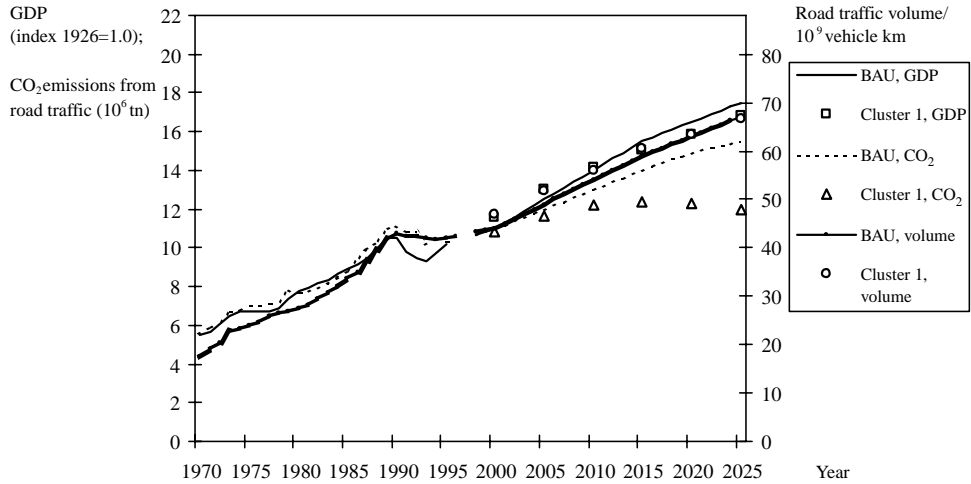
Fig. 4. Comparison between the 'business-as-usual' scenario (BAU) and cluster one.
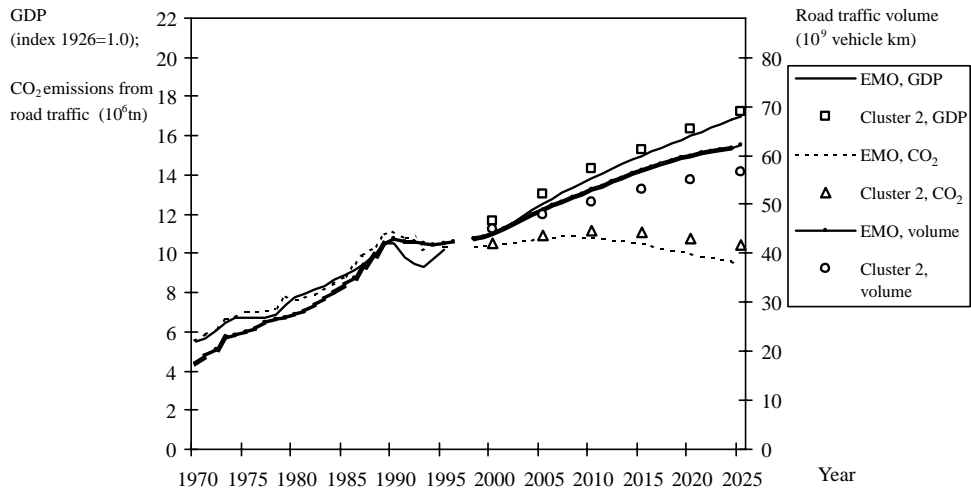

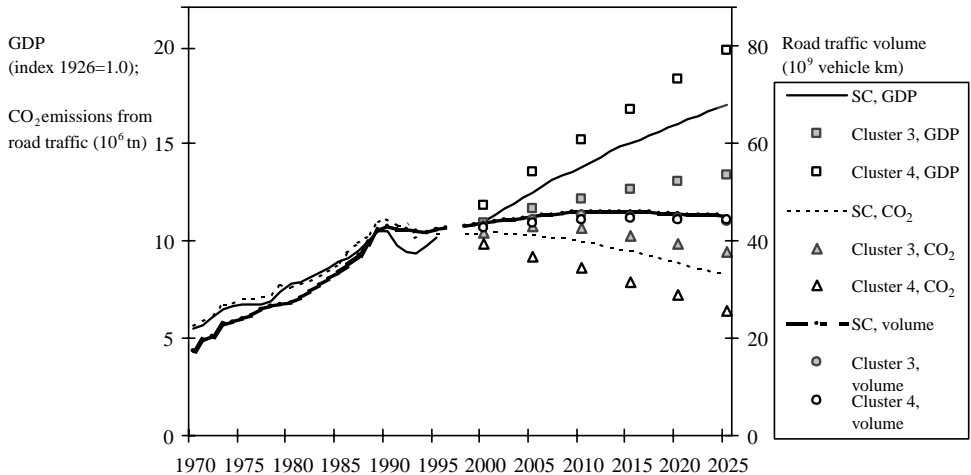Fig. 5. The ecological modernisation scenario (EMO) and cluster two.

Fig. 6. The hypothetical structural change scenario (SC) and clusters three and four.
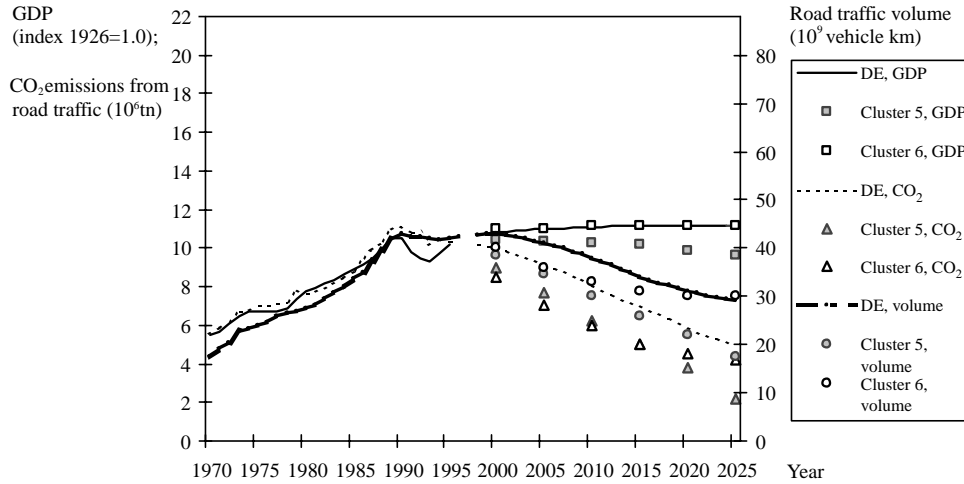
Fig. 7. The hypothetical deep ecology (DE) scenario and clusters five and six.
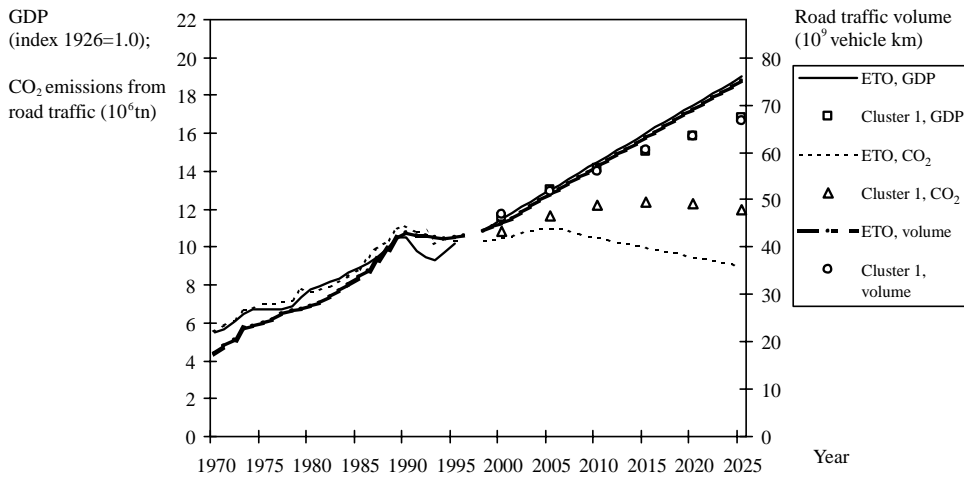

Fig. 8. The economic and technological optimism scenario (ETO) and cluster one.

thus the option of ten alternatives was dropped out. Thus, four and six clusters seemed most relevant (see Tapio, 2000b). Since in this study the purpose is to keep a wide range of policy alternatives inside the Delphi process, six clusters will be examined more closely. If four clusters had been chosen, clusters three and four as well as five and six would have been merged. The reader is invited to ponder whether clusters three and four and on the other hand five and six are different enough to describe different scenarios.

Standard MANOVA and ANOVA tests as well as discrimination analysis cannot be used to test whether the differences between clusters are real, but would rather present circular reasoning (Dubes and Jain, 1979, p. 247; Milligan, 1998, pp. 366–367). The variation

indices of the clusters are presented in Table 2. The median responses of the probable and the preferable future are presented in Table 3 with reference to Karmasin and Karmasin's (1999) study.

4.1. Cluster one: 'business-as-usual plus'

Cluster one is based on the idea that the GDP and road traffic volume would grow at the same rate as before (GDP 60% and volume 55%) and the CO_2 emissions from road traffic would increase more slowly, by 15% (Fig. 4). Cluster one includes four responses of probable future and one of preferable future (STYpro, AKTpro, DODOpro, RHKpro, STYpre). The variation indices of cluster one reveal that the similarity of the

Table 2
Variation indices of the clusters

Cluster/variable	Value[a] 1996	Mean value 2025	Range of 2025 values	SD 2025	SD as per cent[b] 2025
Cluster one: business as usual plus					
Responses: STYpro[c], AKTpro, DODOpro, RHKpro, STYpre[c]					
GDP	10.5	16.8	(16.0; 19.2)	1.39	13
Road traffic volume	42.5	66.7	(64.5; 70.0)	2.05	5
CO_2 emissions of road traffic	10.3	11.9	(10.3; 14.6)	1.93	19
Cluster two: ecological modernisation					
Responses: YMpro, YTV[d]pro, TLpro, LMpro, LALpro, ALpro, LMpre, RHKpre, AKTpre					
GDP	10.5	17.3	(14.1; 19.2)	1.63	15
Road traffic volume	42.5	56.6	(51.2; 59.0)	2.7	6
CO_2 emissions of road traffic	10.3	10.4	(9.2; 11.6)	0.88	9
Cluster three: modest structural change					
Responses: LILIpro, ENEpro, ALpre					
GDP	10.5	13.4	(13.0; 14.1)	0.61	6
Road traffic volume	42.5	43.2	(40.0; 46.0)	3.33	8
CO_2 emissions of road traffic	10.3	9.4	(7.5; 11.8)	2.16	21
Cluster four: optimist structural change					
Responses: LALpre, TLpre, YMpre, YTV[d]pre					
GDP	10.5	19.8	(18.0; 21.6)	1.59	15
Road traffic volume	42.5	44.1	(40.0; 50.0)	4.25	10
CO_2 emissions of road traffic	10.3	6.4	(5.1; 7.6)	1.09	11
Cluster five: radical deep ecology[e]					
Responses: DODOpre, ENEpre					
GDP	10.5	9.7	(9.3; 10.0)	—	—
Road traffic volume	42.5	17.5	(15.0; 20.0)	—	—
CO_2 emissions of road traffic	10.3	2.2	(1.9; 2.5)	—	—
Cluster six: steady state deep ecology[e]					
Response: LILIpre					
GDP	10.5	11.2	—	—	—
Road traffic volume	42.5	30.0	—	—	—
CO_2 emissions of road traffic	10.3	4.2	—	—	—

[a] GDP is measured as an index where the value of GDP_{mer} in real terms in 1926 is 1.0. Road traffic volume is measured in 10^9 vehicle km and CO_2 emissions from road traffic in 10^6 metric ton.

[b] SD is also presented as per cent because it makes the variation of the three variables more comparable.

[c] The label pro stands for probable future and pre for preferable future.

[d] The response of YTV is the operative manager's own view, not the organisation's.

[e] Clusters five and six included only one or two cases and therefore no variation indices were calculated for them.

responses is stronger concerning road traffic volume than for the two other variables (Table 2).

The respondents gave several qualitative arguments supporting this development. The growth of the GDP was explained by the high competitiveness of the Finnish economy in the late 1990s. No great changes were expected concerning the growth rate nor the prevailing materialistic values of people. One respondent in this cluster thought that the Finnish EU membership would be a growth factor and another thought that it would slow down the growth rate in the future.

The main argument for the growth of road traffic volume seemed to be urban sprawl, which was expected

to continue. This sprawl was seen to result from people's desire to live in single family houses and land use planning that would force this trend. Also shops would aggregate to supermarkets locating away from community centres. Urbanisation was thought to generate more leisure trips to the countryside, such as visiting parents and grandparents and summer cottages. The ageing population was expected to be healthier and wealthier in the future, which would also generate more private car traffic. Some respondents in this group argued that the private car is still a status symbol for many Finns.

The arguments for the slower growth of CO_2 emissions from road traffic concerned mainly technical development. Some ambivalency could be seen, as some

Table 3
Comparison of medians of this Delphi study and Karmasin and Karmasin (1999) as percentage of 1996/1997 values[a]

	Probable future[b]		Preferable future	
	GDP	GDP (K&K)	GDP	GDP (K&K)
2010	+34%	+20%	+37%	+20%
2025	+55%	+43%	+62%	+43%
	Road traffic volume	Road traffic volume (K&K)	Road traffic volume	Road traffic volume (K&K)
2010	+18%	+24%	+7%	+14%
2025	+39%	+41%	+5%	+15%
	CO_2 emissions from road traffic	CO_2 emissions from road traffic (K&K)	CO_2 emissions from road traffic	CO_2 emissions from road traffic (K&K)
2010	+10%	+3%	−15%	0%
2025	+5%	−2%	−30%	−10%

[a] The percentages of this study relate to 1996 values, the percentages of Karmasin and Karmasin relate to 1997 values. Karmasin and Karmasin had the exact numbers for 2010 and 2030, the figures for 2025 have been estimated.

[b] Karmasin and Karmasin did not have road traffic volume measured in vehicle km as a separate variable. The percentage is estimated from passenger km driven with private motorised vehicles and road freight transport measured by tonne km without assuming further drop of number of passengers in a vehicle nor growth of lorries. It was further assumed that 80% of vehicle km would be driven by private motorised vehicles.

respondents thought their CO_2 emissions curve as optimistic whereas some thought it to be pessimistic. No great policy measures towards the restriction of CO_2 emissions was assumed. RHK, AKT and DODO regarded the development of cluster one as unpreferable and STY as preferable, which seems to explain the optimism-pessimism dilemma.

In Fig. 4, cluster one is compared with the theoretical BAU scenario. The GDP and road traffic volume curves are almost identical to BAU, but some technical improvement is expected concerning CO_2 emissions.

4.2. Cluster two: ecological modernisation

In cluster two the GDP would increase by 65%, but the road traffic volume would increase more slowly, by 35%. The CO_2 emissions would stay at the level of 1996–2025 (Fig. 5). Cluster two includes six responses of probable future and three of preferable future (YMpro, YTV*pro, TLpro, LMpro, LALpro, ALpro, LMpre, RHKpre, AKTpre). The variation of road traffic volume and GDP within cluster two is larger than in cluster one, whereas the variation of CO_2 emissions is smaller (Table 2).

According to the respondents of cluster two, the globalisation of markets would result in a continuous high growth rate of the economy in China and South-Eastern Asia and later in Russia, which would have effect on Finland as well. One respondent also mentioned South America as a high growth area in the future. Information technology in particular would continue to expand the economy, and Finland was seen to possess high competitiveness in this sector.

The respondents that considered the development in cluster two preferable argued that high GDP growth is essential to repay governmental debt and decrease unemployment. One respondent regarded a more even

income distribution as preferable and thought that there would be more to redistribute, if the growth would be rapid (AKT). Another thought that the tax rate is too high in Finland and that a high growth would allow some relief (LM). Respondents of RHK stated that a moderate stable growth is one starting point of their organisation. Environment was not seen as a restriction to the growth rate presented in cluster two.

However, one response that was grouped to cluster two had qualitatively different views compared to the others concerning GDP growth (AL). The respondent stated that world population will increase at a rate that would affect the depletion of environmental resources, which in turn would slow down consumption and affect Finnish export. Information technology would have a marginal growth effect because the markets are mainly in the developed countries, and there would not be a great potential for dematerialisation. However, the service economy would increase. These factors would produce fairly slow growth. The organisation produced the lowest estimate of GDP in the cluster (see Table 2).

In cluster two, there were different views concerning urban structure. The respondents that regarded the development of cluster two as probable, saw the traffic volume connected to urban sprawl and the respondents that considered cluster two preferable, saw urban infill connected to the volume figures presented. The latter group stated that a lower road traffic volume growth would be preferable, but this was the lowest realistic estimate. The respondents of cluster two agreed with that of cluster one that urbanisation would result in some extra leisure trips to the countryside, but in cluster two urbanisation was seen to slow down traffic volume growth as a net effect.

The arguments concerning the travel behaviour of the ageing population differed from that of cluster one. Respondents in cluster two thought that in the future

elderly people would drive less than middle aged people, resulting in a negative net effect on road traffic volume. Some respondents thought that the private car is losing its role as a status symbol and information technology would take that role. The saturation of car density would occur before 2025 because of a shift of values towards the non-material and due to demographic factors.

The taxes of car ownership and car use were thought to stay relatively high in the cluster two responses. Some subsidies for surface public transport were seen as important. The infrastructure for cycling and walking would be improved as well. Improving logistics and industrial dematerialisation would restrict the growth of road freight transport.

The arguments concerning fuel efficiency were similar to cluster one. The CO_2 emissions per vehicle km presented in cluster two would be the same as in cluster one, which indicates the difference concerning traffic volume between the clusters. Many respondents referred to an agreement between the EU and the car industry organisation (ACEA) that would lower the fuel consumption to 5.8 litres/100 km of new passenger cars by 2008. Most respondents did not present a significant market share for cars using alternative energy sources, although one respondent anticipated an approximate share of 10% for electric or hydrogen cars by 2025 (YM). Stricter speed limits were also mentioned to restrict the growth of CO_2 emissions. The growth of engine power was expected to reach saturation. One respondent considered preferable European wide CO_2 taxation (RHK).

In Fig. 5, cluster two is compared with the theoretical ecological modernisation scenario (EMO). The GDP and CO_2 emissions would be same in the EMO scenario but the road traffic volume would increase faster. A slightly less technical improvement was expected in cluster two than in the EMO scenario.

4.3. Cluster three: 'modest structural change'

Cluster three contains slower growth of the GDP, 30%, and almost no growth in road traffic volume, 5%. The CO_2 emissions would slowly begin to decrease by some 10% (Fig. 6). Cluster three includes two responses of probable future and one of preferable future (LILIpro, ENEpro, ALpre). The variation in road traffic volume and CO_2 emissions in cluster three is larger than in clusters one and two. The variation of GDP on the other hand is smaller in cluster three (Table 2).

According to the responses, enviromental problems would constrain the growth of the economy. Also, non-material values would become more important in the future. Two respondents were suspicious about the positive impact of information technology on the

economy, because Finnish information technology (IT) firms could move production abroad or the IT enthusiasm was seen as exaggerated. One respondent (ENE) expected dematerialisation due to IT. The service economy was emphasised by all three, although AL and LILI seemed suspicious about the potential for non-material growth of the GDP. One respondent (ENE) stated that the growth of the GDP could be slower because of less wars or other non-preferable forms of production in the future.

In cluster three, urbanisation was regarded as a factor lowering road traffic volume. Also, urban infill was expected to result in a no-growth situation as surface public transport would gain more of the market share. Whether this would increase or reduce traffic to the countryside was not agreed on. AL and ENE expected more traffic to summer cottages, whereas LILI saw a decline in this trend as young people would be more interested in urban surroundings, e.g. parks and beaches.

Congestion was seen as a driving force for policy making toward a more public transport friendly direction by LILI and ENE. They expected, for example, that the tax allowance for employment related trips by private car would be abandoned. AL, in turn, considered that urban infill and the changing values of people would restrict road traffic volume growth and they did not make any policy recommendations to restrict car use.

A clear feature of the responses of cluster three was the assumption of a more calm lifestyle. People were expected to search for peace and silence in contrast to the more hectic working life. Also, consumption of services would increase. This would result in a stagnating traffic volume growth as well, especially passenger car traffic, which was referred to as something people would be fed up with and was considered old-fashioned. Freight transport was mentioned only in one response declaring that better logistics would constrain the growth of deliveries.

As for CO_2 emissions in road traffic, an insignificant improvement in fuel efficiency was expected (the responses varied considerably, see Table 2). LILI was the most critical, considering that improvement in fuel efficiency is not probable, because the oil industry and car industry are too closely connected. Also, the EU norms would not be effective because the norm test is not applicable to cold climate countries such as Finland and people would still be buying larger cars. ENE and AL expected more improvement in fuel efficiency. AL also promoted eco-driving due to the better education of drivers and car salesmen concerning the choice of a car and driving habits. Future car buyers would desire more beauty and more space but not more engine power. ENE simply regarded the combustion engine as old-fashioned.

4.4. Cluster four: 'optimist structural change'

Cluster four includes a high growth in GDP, 90%, but almost no growth in road traffic volume, only 5%, and a clear decrease of CO_2 emissions by 40% (Fig. 6). Cluster four includes no responses of probable future but four responses of preferable future (LALpre, TLpre, YMpre, YTV*pre). The variation in road traffic volume is larger than in clusters one to three, but the responses seem to be similar in terms of the CO_2 emissions of road traffic (Table 2).

The responses in cluster four were clearly oriented toward non-material growth and represent a more optimistic version of cluster three. Contrary to cluster three, stable strong growth of the GDP was regarded as improving the quality of life. Respondents considered the goals of good quality environment and GDP growth compatible. Stable growth was also regarded as a requirement for abatement of the negative externalities of economic action.

Road traffic volume was seen as an indicator of the material economy and therefore further growth was not recommended. The respondents thought that the current level of mobility in Finland is high enough for a good quality of life and low enough to provide good opportunities for a reduction in emissions. Further growth would bring more congestion, accidents and emissions. Clear potentials for rationalisation of production and logistics of delivery were seen by the better use of information technology. This would improve the efficiency of the economy and therefore allow investments in more profitable areas than transport.

According to the responses, the most important factors for stopping road traffic volume growth were urbanisation and urban infill. These were considered to favour public transport. Fast trains were expected to compete with passenger cars and aeroplanes in longer trips and buses in shorter trips. Also pedestrian and bicycle traffic was emphasised on short distances. Some freight would be shifted from road to rail as well.

The respondents presented several policy instruments for the mode shifts, including slower speed limits, higher fuel taxes, etc. Also, changes in people's lifestyles were regarded as preferable and essential for the development described by the cluster.

The respondents expected a clear improvement in fuel efficiency and therefore a reduction of CO_2 emissions from road traffic. One argument was that the climate policy debate has only recently begun and the fuel efficiency improvement will be seen more clearly in the future. Two respondents in cluster four viewed a 20–30% market share for vehicles of alternative energy sources in 2025 (YM and YTV*).

Fig. 6 compares the hypothetical structural change (SC) scenario and clusters three and four. All agree that road traffic volume would (or should) stay at the level of the 1990s. Surprisingly there seem to be two variations to this idea, cluster three seeking for low growth and a modest improvement in eco-efficiency and cluster four for a high growth and eco-efficiency.

4.5. Cluster five: 'radical deep ecology'

Cluster five contains a slow negative GDP growth, −10%, and a steep decrease in road traffic volume by 60% back to the level of the late 1960s. Also CO_2 emissions would decrease steeply by 80% (Fig. 7). Cluster five includes no responses of a probable future but two responses of a preferable future (DODOpre, ENEpre). The range of the variables can be seen in Table 2.

According to the responses of cluster five, the material standard of living is already high enough in Finland. Further growth would require more working hours and a more hectic lifestyle, which were seen as undesirable. The GDP also includes unnecessary and nonpreferable production of items such as weapons and unnecessary luxury goods such as ski-doos, etc. The respondents regarded a calmer and a more peaceful lifestyle as preferable. This would produce a good quality of life but less GDP. A more even income distribution would improve the situation of the poor and shorter working hours would decrease unemployment even in the zero growth GDP economy.

The respondents anticipated great potential for immaterialisation via information technology. For example, new thin displays could substitute paper printing which would clearly decrease freight transport volume in Finland. Telecommunication would also have good potential as a substitute for real traffic.

The responses in cluster five included urbanisation as a factor in the decrease of traffic volume, although there were differences: ENE stated that the rapid movement to the Helsinki capital region should be stopped and emphasis should be placed to little villages and the countryside; whereas DODO was more city oriented. Both anticipated growth for small towns.

The respondents considered urban infill preferable and essential, especially for pedestrian and bicycle traffic, which were strongly emphasised. Construction of supermarkets would be restricted and small local shops emphasised. Aesthetically more attractive cities and public transport vehicles would enable people to enjoy urban life more, cutting down the amount of travel to summer cottages. DODO stated that the generation that is born in cities and towns would have more urban leisure time activities in the future, which would decrease leisure traffic to the countryside. In cluster five, there would be a clear price upheaval of road traffic and flights as well.

As for the CO_2 emissions of road traffic, a more rapid development in technology was preferred than in the probable future stated by the respondents. This would mean electric cars and hybrid electric vehicles initially, later even solar vehicles (mainly Southern countries). Car taxation would strongly favour lighter and smaller vehicles. Fig. 7 compares the deep ecology (DE) scenario with clusters five and six.

4.6. Cluster six: 'steady state deep ecology'

Cluster six is a slightly less radical version of cluster five, having very slow growth of the GDP, 5% for the whole period, and a clear decrease in traffic volume by 30%. Also, the CO_2 emissions would decrease clearly by 60% (Fig. 7). Cluster six consists of only one response of a preferable future (LILIpre). The values for 2025 are shown in Table 2.

The respondent in cluster six criticised the GDP for that measuring everything in monetary terms is principally wrong. Quality of life could improve even without monetary growth.

To reduce road traffic volume, the respondent presented urbanisation and urban infill as important factors. People would be more interested in parks and beaches than in summer cottages. The people using summer cottages would rent a car instead of owning one. According to the respondent, values are already changing and the car is becoming less of a status symbol than computers and mobile phones.

Also, more subsidies for surface public transport were recommended, but not to the less used countryside lines. Instead, money should be put into cities and intercity connections. This would reduce costs and generate more customers. Another point of emphasis would be more and better bicycle lanes.

Mitigating climate change is one principle of action of the respondent organisation and therefore steep reductions of CO_2 emissions due to road traffic were considered preferable. Technological development was expected to become more rapid than previously, because curtailing CO_2 emissions was seen to be gaining importance in the policy agenda internationally as well as nationally.

5. Discussion

The theoretical scenarios seem to give relevant interpretations to the results. Figs. 4–8 illustrate the positions of the clusters in relation to the nearest theoretical scenarios. A slightly improved 'business-as-usual' cluster could be identified as well as a version of ecological modernisation. It was interesting to find two quite different versions of structural change and two versions of deep ecology. However, a cluster that would

have correlated with the hypothetical economic and technological optimism (ETO) scenario is missing from the six clusters. Closest to the ETO scenario is cluster one, which is illustrated in Fig. 8.

With regard to the growth-oriented policies of Finland and the weak criticism against them by strong interest groups (see Wilenius and Tirkkonen, 1997), the absence of an economic and technological optimism cluster seems somewhat implausible and indicates a bias in the study sample. TT might be expected to present this line of thought but it produced values only for GDP (21 for year 2025) and CO_2 emissions from road traffic (8.5 for year 2025) and omitted road traffic volume. Another option is that the most growth oriented interest groups simply do not wish the CO_2 emissions to be reduced because of the costs involved. But it is also possible that only a few organisations in the transport field do believe in the most techno-optimistic views. Have the growth optimists moved towards the optimists' version of structural change and ecological modernisation?.

All clusters, except cluster one, are based on the idea that GDP will grow faster than road traffic volume (immaterialisation), which will in turn grow faster than CO_2 emissions (dematerialisation). Cluster one also expects dematerialisation. Thus, the interest groups of transport policy in Finland expected a clear change in the relations of the variables.

Some comparisons with the Karmasin and Karmasin (1999) Delphi study can be made, however keeping in mind the differences: it was carried out with a European wide context, included over 100 panellists, had two rounds of probable future and one separate round of preferable future, and was sampled by co-nomination of individual experts. All the rounds were carried out with a questionnaire; no historical background data was served to the panellists and the respondents answered by index numbers instead of manual drawing. No cluster analysis was calculated and the results were reported in terms of median and interquartiles. The medians found by Karmasin and Karmasin (1999) and in this study regarding the probable and prefererable future are compared in Table 3.

In this study the panellists expected and wished both dematerialisation and immaterialisation. The expert respondents of Karmasin and Karmasin seemed not to believe in immaterialisation in the probable future but did consider it preferable. The expert respondents of Karmasin and Karmasin seemed to be more pessimistic regarding the reduction of CO_2 emissions in the preferable future compared to the interest groups of this study. (Table 3.)

The qualitative arguments produced by the respondents in this study included regional and urban structure as major factors affecting the traffic system and formed also the basis for policy recommendations. Although there has been a vast amount of work on these

mechanisms in transport engineering, transport economics and geography (e.g. Lahti and Harmaajärvi, 1992; Jansen, 1993, pp. 114–122; Matinheikki, 1996; Vickerman, 1999; Simmonds and Still, 1999), they seem to be poorly discussed in the theoretical literature of environmental policy. Here, transportation research can make a precious contribution to the general theoretical discussion of environmental policy.

Three weak signals of mechanisms restraining road traffic volume growth can be detected from the interviews, all anticipating a change in the traffic behaviour patterns of urban people. First, it is possible that the attractiveness of leisure time activities in cities will increase and may offset the trend to drive to summer cottages in the countryside. Second, there are indications of a reduction in the acquisition of driving licences especially by the young people due to increasing expenditure of money and time on mobile phones and computers. Third, the possible increase in healthy activities could result in an upward trend in bicycle commuting. These weak signals had little to do with anticipation of the rise of environmental values affecting traffic behaviour.

Finally, certain lessons can be learned about the methodological approach. Compared to ordinary committee work, the disaggregative Delphi process seems to bring out more diverse policy alternatives. The Working Group of CO_2 Emissions for Road Transport in Finland had two alternatives, the "probable" and "0-target", the difference being $+5\%$ and 0% growth of CO_2 emissions between 1990 and 2010. Passenger car traffic volume growth in the probable alternative was $+24\%$ and in the 0-growth alternative $+18\%$ (Ministry of Transport, 1999a). The working group could be said to have a narrow perspective on future possibilities.

There is no need to debate whether heuristic scenarios or empirically tested formal models are better because they have different roles (Schwarz et al., 1982). Rather Delphi and other heuristic scenario methods could provide new ideas regarding important factors and mechanisms which could be incorporated into 'what-if' models. The qualitative arguments included in a quantitative cluster varied considerably, however. This restricts the formation of consistent scenarios directly from the data. It seems appropriate to conclude that the disaggregative Delphi approach of this study can be used to form the core of a set of scenarios but it is still necessary to use some heuristic common sense to solve the remaining inconsistencies.

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References

Acutt, M.Z., Dodgson, J.S., 1998. Transport and global warming: modelling the impacts of alternative policies. In: Banister, D. (Ed.), Transport Policy and the Environment. E & FN Spon, Cornwall, pp. 20–37.

Arentze, T., Hofman, F., Timmermans, H., 1999. Deriving decision rules from activity diaries. In: Meersman, H., van de Voorde, E., Winkelmans, W. (Eds.), World Transport Research, Proceedings of Eighth World Conference on Transport Research: Transport Modelling/Assessment, Vol. 3. World Conference on Transport Research Society (WCTRS) & Pergamon, Amsterdam, pp. 51–64.

Baker, S., Kousis, M., Richardson, D., Young, S., 1997. Introduction. In: Baker, S., Kousis, M., Richardson, D., Young, S. (Eds.), The Politics of Sustainable Development. Theory, Policy and Practise within the European Union. Routledge, London, pp. 1–40.

Banister, D., 1998. Introduction: transport Policy and the Environment. In: Banister, D. (Ed.), Transport Policy and the Environment. E & FN Spon, Cornwall, pp. 1–16.

Baum, H., 1995. Separating economic development from traffic growth. In: ECMT, Transport Economics: Past Trends and Future Prospects, Round Table 100. Economic Research Centre & European Conference of Ministers of Transport (ECMT), Paris, pp. 81–84.

Bell, W., 1997. Foundations of Futures Studies: Human Science for a New Era, Vol. 1. Transaction Publishers, New Brunswick.

Bouwman, M., 2000. Tracking transport systems: an environmental perspective on passenger transport modes. Doctorate Thesis, Geo Press, Groningen.

Button, K.J., 1996. Transport Economics, 2nd Edition. Edward Elgar, Cambridge.

Chiquetto, S., Blackledge, D., 1999. Estimating the energy and emission impacts from the implementation of transport measures. In: Meersman, H., van de Voorde, E., Winkelmans, W. (Eds.), World Transport Research, Proceedings of Eighth World Conference on Transport Research: Transport Policy, Vol. 4. World Conference on Transport Research Society (WCTRS) & Pergamon, Amsterdam, pp. 213–226.

Cohen, S., Demeritt, D., Robinson, J., Rothman, D., 1998. Climate change and sustainable development: towards dialogue. Global Environmental Change 8 (4), 341–371.

Dubes, R., Jain, A.K., 1979. Validity studies in clustering methodologies. Pattern Recognition 11, 235–254.

Dunlap, R.E., 1983. Comment: ecological "news" and competing paradigms. Technological Forecasting and Social Change 23, 203–206.

Eurostat, 1999. EU Transport in Figures 1998. Statistical Pocket Book. DG VII, Eurostat. Available at http://europa.eu.int/en/comm/dg07/tif.

FinnRA, 1997. Koko maan liikennesuorite autolajeittain vuosina 1970-1997/2020E. The website of Finnish Road Administration,

http://www.tieh.fi/aikas/liiks.htm. [Road traffic volume by mode in the whole country 1970-1997/2020(forecast)]

Goodwin, P.B., 1995. Conclusions of the Chairman. In: ECMT, Transport Economics: Past Trends and Future Prospects, Round Table 100, Economic Research Centre & European Conference of Ministers of Transport (ECMT), Paris, pp. 217–224.

Gupta, U.G., Clarke, R.E., 1996. Theory and Applications of the Delphi Technique: a Bibliography (1975–1994). Technological Forecasting and Social Change 53, 185–211.

Hinterberger, F., Schmidt-Bleek, F., 1999. Dematerialization, MIPS and factor 10: physical sustainability indicators as a social device. Ecological Economics 29 (1), 53–56.

Huber, J., 1995. Nachhaltige Entwicklung: strategien für eine ökologische und soziale erdpolitik. Edition Sigma, Berlin.

IEA, 2000. The Road from Kyoto: Current CO_2 and Transport Policies in the IEA. International Energy Agency, IEA Publications 9, Paris.

IPCC, 1996. Climate change 1995. Impacts, adaptations and mitigation of climate change: scientific-technical analyses. In: Watson, R.T., Zinyowera, M.C., Moss, R.H., Dokken, D.J. (Eds.), Contribution of Working Group II to the Second Assesment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York.

Jansen, G.R.M., 1993. Commuting: home sprawl, job sprawl and traffic jams. In: Salomon, I., Bovy, P., Orfeuil, J-P. (Eds.), A Billion Trips a Day: Tradition and Transition in European Travel Patterns. Transportation Research, Economics and Policy, Kluwer Academic Publishers, Dordrecht, pp. 101–127.

Jänicke, M., 1988. Ökologische Modernisierung. Optionen und Restriktionen präventiver Umweltpolitik. In: Simonis, U.E. (Ed.), Präventive Umweltpolitik. Campus, Frankfurt am Main, pp. 13–26.

Jokinen, P., 1995. Ekologinen modernisaatio ja rakennemuutos ympäristöpolitiikkana. In: Massa, I. and Rahkonen, O. (Eds.), Riskiyhteiskunnan talous. Suomen talouden ekologinen modernisaatio, Gaudeamus, Helsinki. [Ecological Modernisation and Structural Change as Environmental Policies, in Finnish, pp. 319–333.]

Kaivo-oja, J., 1999. Alternative scenarios of social development: is analytical sustainability policy analysis possible? How? Sustainable Development 7 (3), 140–150.

Karmasin, F., Karmasin, H., 1999. Delphi-Studie "Zukunft der Mobilität", Bericht, Institut für Motivforschung (ifm), Archiv-Nummer: 5249, available at http://www.oeamtc. at/aka_publ, 74pp. [The website includes also English version but it was not downloadable when the manuscript of this article was written.]

Kokkarinen, V., 1991. Autokanta-ja liikenne-ennusteita eräissä maissa. Tiehallitus, Tielaitoksen selvityksiä 52/1991, Helsinki. [Forecasts of Automobile Stock and Traffic in Selected Countries, in Finnish]

Kuusi, O., 1999. Expertise in the future use of generic technologies. Epistemic and methodological considerations concerning Delphi studies. Acta Universitatis Oeconomicae Helsingiensis A-159, Helsinki School of Economics and Business Administration, HeSE Print, Helsinki.

Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1997. http://www.unfccc.de/fccc/docs/cop3/protocol.html.

Lahti, P., Harmaajärvi, I., 1992. Yhdyskuntarakenne ja kestävä kehitys. Research Report no 1/1992, Ministry of the Environment, Physical Planning and Building Department & VAPK-publishing, Helsinki. [Urban Form and Sustainable Development: International Experiences, in Finnish, Abstract in English]

Lampinen, R., 1998. Tieliikenne ja ympäristö—tilannekatsaus. Tulevaisuuden näkymiä 4, 5–11. [The State of Road Traffic and the

Environment, in Finnish, also available at http://www.tieh.fi/tulnak.htm]

Linstone, H.A., Turoff, M. (Eds.), 1975. The Delphi Method. Techniques and Applications. Addison-Wesley Publishing Company, Don Mills.

Mäkelä, K., 1997. Suomen liikenteen hiilidioksidipäästöt. The website of Technical Research Centre Finland, http:www.vtt.fi/yki/yki6/liisa/co2dats.htm. [The Carbon Dioxide Emissions from Traffic in Finland.]

Massa, I., 1995. Epävarman yhteiskunnan ympäristöpolitiikka. In: Massa, I. and Rahkonen, O. (Eds.), Riskiyhteiskunnan talous. Suomen talouden ekologinen modernisaatio. Gaudeamus, Helsinki, pp. 7–38. [The Environmental Policy of an Unsecure Society, in Finnish]

Matinheikki, M., 1996. Tieliikenteen energiankulutus ja kaupunkirakenne—yhteyksiä eri kokoluokan taajamissa. FinnRA Publications 14/96, Finnish Road Administration & Edita, Helsinki. [Road Traffic Energy Consumption and Urban Structure, in Finnish, Summary in English.]

Milligan, G., 1998. Cluster analysis. In: Kotz, S., Read, C.B. & Banks, D.L. (Eds). Encyclopedia of Statistical Sciences, Vol. 2. Wiley, New York, pp. 120–125.

Ministry of Transport and Communications, 1999a. Liikenteen vertailutietoja eri maista. Publications of the Ministry of Transport and Communications 29/99. Edita, Helsinki. [Comparative Research on Transport in Various Countries, in Finnish, Abstract in English.]

Ministry of Transport and Communications, 1999b. Toimenpiteet tieliikenteen hiilidioksidipäästöjen vähentämiseksi, Publications of the Ministry of Transport and Communications 16/99, Edita, Helsinki. [Measures to Decrease Carbon Dioxide Emissions of Road Traffic. Publication of the Working Group of CO_2 Emissions, in Finnish, Abstract in English.]

Mol, A.P.J., 1996. Ecological modernisation and institutional reflexivity: environmental reform in the late modern age. Environmental Politics 5 (2), 302–323.

Naess, A., 1976. Økologi, samfunn og livsstil: Utkast til en økosofi. 5th Edition, Universitetsforlaget, Oslo. [In Norwegian, a revised edition available in English: Nćss, A., 1990. In: Rothenberg, D. (transl), Ecology, Community and Life-Style, Cambridge University Press, Cambridge.]

OECD, 1997. Environmentally sustainable transport. Final Report on Phase II of the OECD EST Project, Synthesis Report, Vol. 1. Environment Directorate, Environment Policy Committee, Working Party of Pollution Prevention and Control, Working Group on Transport, ENV/EPOC/PPC/T(97)1/FINAL, 81789. Available at http://www.oecd.org/est.

Rotondi, A., Gustafson, D., 1996. Theoretical, methodological and Practical issues arising out of the Delphi method. In: Adler, M., Ziglio, E. (Eds.), Gazing into the Oracle. The Delphi Method and its Application to Social Policy and Public Health. Jessica Kingsley Publishers, London, pp. 34–55.

Sairinen, R., 1996. Suomalaiset ja ympäristöpolitiikka. *Statistics Finland, Researches* 217, Helsinki. [Finns and Environmental Policy, in Finnish.]

Sasaki, K., Morikawa, T., Kawakami, S., 1999. A discrete choice model with taste heterogeneity using SP, RP and attribute importance ratings. In: Meersman, H., van de Voorde, E., Winkelmans, W. (Eds.), World Transport Research, Proceedings of Eighth World Conference on Transport Research: Transport Modelling/Assessment, Vol. 3. World Conference on Transport Research Society (WCTRS) & Pergamon, Amsterdam, pp. 39–49.

Schwarz, B., Svedin, U., Wittrock, B., 1982. Methods in Futures Studies. Problems and Applications. Westview Press, Boulder, CO.

Simmonds, D., Still, B., 1999. DELTA/START: adding land use analysis to integrated transport models. In: Meersman, H., van de Voorde, E., Winkelmans, W. (Eds.), World Transport Research,

Proceedings of Eighth World Conference on Transport Research: Transport Policy, Vol. 4. World Conference on Transport Research Society (WCTRS) & Pergamon, Amsterdam, pp. 1–14.

Skamris, M.K., Flyvbjerg, B., 1997. Inaccuracy of traffic forecasts and cost estimates on large transport projects. Transport Policy 4 (3), 141–146.

Socialdata, 1992. Kleine Fibel vom Zufussgehen und anderen Merkwürdigkeiten. Socialdata, München.

Statistics Finland, 1997. Volyymi-ideksit 1860–1995. The website of Statistics Finland, http://www.stat.fi/tk/to/sarjat.html. [Volume indexes 1860–1995 (of GDP of Finland).]

Steg, L., Arnold, M., Ras, M., van Velzen, E., 1997. Maatschappelijke en individuele determinanten van autogebruik: Toepassing van het model Determinanten van milieurelevant consumentengedrag. Sociaal en Cultureel Planbureau, Rijswijk. [Societal and Individual Determinants of Car Use, in Dutch, Summary in English.]

Still, B.G., May, A.D., Bristow, A.L., 1999. The assessment of transport impacts on land use: practical uses in strategic planning. Transport Policy 6 (2), 83–98.

Tapio, P., 1996. From technocracy to participation? Positivist, realist and pragmatist paradigms applied to traffic and environmental policy futures research. Futures 28 (5), 453–470.

Tapio, P., 2000a. Scenarios for traffic CO_2 policy in Finland for 2025. TUTU Publications 2, Finland Futures Research Centre, Turku School of Economics and Business Administration, Turku.

Tapio, P., 2000b. Delphi with cluster analysis: a tool for systematic scenario formation for the CO_2 policy of traffic sector in Finland. Paper presented at the seminar "The Quest for the Futures: A Methodology Seminar of Futures Studies", 13–15 June, 2000, Turku, Finland. World Futures Studies Federation & Finland Futures Research Centre. 14pp.

Tengström, E., 1999. Towards Environmental Sustainability? A Comparative Study of Danish, Dutch and Swedish Transport Policies in a European Context, Ashgate, Wiltshire (UK).

Turoff, M., Hiltz, S.R., 1996. Computer-based Delphi processes. In: Adler, M., Ziglio, E. (Eds.), Gazing into the Oracle. The Delphi Method and its Application to Social Policy and Public Health. Jessica Kingsley Publishers, London, pp. 56–85.

Vickerman, R., 1999. The Transport Sector, New Economic Geography and Economic Development in Peripheral Regions. In: Beuthe, M., Nijkamp, P. (Eds.), New Contributions to Transportation Analysis in Europe. Ashgate, Gateshead, pp. 45–66.

von Wright, G.H., 1986. Vetenskapen och förnuftet. Tryckeri och Tidnings Ab, Borgå. [Science and Reason, in Swedish.]

Wilenius, M., Tirkkonen, J., 1997. Climate in the making: using Delphi for Finnish climate policy. Futures 29 (9), 845–862.

Ziglio, E., 1996. The Delphi method and its contribution to decision-making. In: Adler, M., Ziglio, E. (Eds.), Gazing into the Oracle. The Delphi Method and its Application to Social Policy and Public Health. Jessica Kingsley Publishers, London, pp. 3–33.