Eur J Futures Res (2015) 3: 10
DOI 10.1007/s40309-015-0069-6

ORIGINAL ARTICLE

Technopolis, shared resources or controlled mobility? A net-based Delphi-study to explore visions of future urban daily mobility in Norway

Tom Erik Julsrud [1] · **Tanu Priya Uteng** [1]

Received: 29 March 2015 / Accepted: 27 July 2015 / Published online: 13 August 2015

Abstract It is widely recognized that transformation of urban areas are urgent to meet the demands for more efficient and environmental friendly transportation in the future. Although there are general agreements on the need for change, different ideas and visions for the future dominate across different groups of stakeholders and academics. In this paper we explore various views on the future of everyday travelling in urban regions, 30–40 years ahead, focussing in particular on four larger urban areas in Norway. Based on an innovative web-based Delphi-study, involving 280 national experts, various conceptions of future urban travelling is explored. An explorative factor analysis (principal component analysis) is applied to reveal three slightly different understandings of how the urban future may look like in 2050. These three visions - labelled as "Controlled mobility", "Technopolis" and "Shared mobility"- suggests slightly different scenarios' for the future of urban travelling.

Keywords Urban travels · Delphi-study · Scenarios · Mobile technologies

Introduction

Predicting future transport scenarios can best be described as mythical because of the numerous factors that feed in to creating transport realities. Predictions are needed, however, and the transport sector to date has taken shelter in the "predict and provide" approach based on transport modelling and other methods rooted in statistical computing. It has been argued that the dominance of predictive four-stage travel demand models and data requirements has resulted in most representations of travel behaviour being simply a projection of present-day travel behaviour. There are of course exceptions that provide deeper insights into daily activities and their effect on travel behaviour, but they are limited and aim mainly at the development of trip generation rates for use in the first stage of the four-stage travel demand forecasting procedure. The transport planning field has thus been grappling with how to decipher the complex relationships between behaviour, preferences, constraints, effects of future trends and the resultant changing travel behaviours.

Empirical findings have documented that individuals employ a wide variety of strategies when faced with restrictions imposed by transport policies (e.g., decreased transit services, gasoline restrictions) [1–3], strategies that range from simple modal shifts to more complex adaptations involving trip consolidation (i.e., chaining), activity re-scheduling and destination substitution. Conventional travel demand models do not reflect (and hence predict) these complex responses, however, because of several theoretical shortcomings. In addition, estimation of the likely impacts of various activity system policies (e.g., flexitime, extended hours of service facilities) is beyond the realm of the present models, which means that separate understandings have to be built on various episodes affecting travel behaviour and made into concrete variables for the transport modelling process.

It is now widely accepted that in order to identify where gaps in knowledge exist, it is first necessary to conceptualise what a more comprehensive or complete knowledge of travel behaviour should encompass. The difference between the respective scopes of "complete" and current knowledge would thus represent gaps in knowledge or understanding.

✉ Tom Erik Julsrud
tej@toi.no

1 Institute of Transport Economics (TØI), Gaustadalléen 21, O349 Oslo, Norway

Numerous possible ways have been put forward for conceptualising and measuring the scope of such complete knowledge. For example, it could be conceptualised in terms of four interrelated dimensions: the personal, functional, logistical and temporal, and their interactions with the respective technologies. Travel is undertaken by people, and the particular circumstances of each individual influence his or her travel opportunities and choices (i.e., the personal dimension). A person's need to travel derives from their desire to engage in a variety of activities distributed across space (i.e., the functional dimension). In order to move between activity sites, people need to make (sometimes highly complex) arrangements regarding how they will travel (i.e., the logistical dimension). Where and how people travel changes over time in response to changes in their personal circumstances and broader environment (i.e., the temporal dimension).

A need to adopt a policy-sensitive approach to modelling travel behaviour based on activity pattern analysis has been recognised and the theoretical framework by which to recognise the wide range of interdependencies associated with an individual's travel decisions in a constrained environment has subsequently evolved. Travel has thus come to be viewed as input to a more basic process involving activity decisions, and has started to operate in a broader context than in single-trip methodologies. A significant element in this development involves formulation of a theory and model of individual choice set formation that includes the effect of current and future environmental/household constraints and of individual limitations with respect to information-processing and decision-making.

To this end, Shergold et al. [4] note "there is a growing concern that innovations in 'non-transport technologies' are not considered in projections of future travel demand and formulation of transport policy" [5, 6]. The insertion and influence of technology in future transport with special reference to public transport consumption is one such arena. Scenario-planning exercises have emerged as powerful tools addressing these concerns and are gaining wide recognition in the field of transport planning. This is especially the case when analysing where future transport technologies are expected to play a vital role.

In this paper our aim is to contribute to building a stratified understanding of the scenarios we might be looking at with respect to future daily mobility. In past decades, various scenarios of future mobilities have been visualised [7–11], central among them being challenges related to climate change from growing emissions of CO_2 and potential strategies towards achieving changes. Concerns about the risk of terrorism and criminality, erosion of the modern state at its democratic systems and the rise of neoliberalism have also been discussed. The role of new technologies, however, has been recognised as the most influential parameter for future mobility. Dennis and Urry [12] have proposed three general visions of the future of mobilities that capture several dimensions represented in much of the current literature: "Local Sustainability" describes an environmental-communitarianism future where long-distance travel is reduced because of resource shortages and where localised low carbon journeys by non-motorised forms of transport and movement come to dominate alongside motorised forms. A second vision, labelled "Regional Warlordism", describes a future witnessed by an implosion of mobility, where movement is hard to achieve, dangerous outside certain boundaries and reliant on ingenuity of skills to maintain decaying car culture. In their final scenario, "Digital Networks of Control", the author describes an Orwellian style future where collective automation of movement under constant surveillance replaces autonomous separateness with obvious implications for human freedom of movement. These visions have proved to be influential in academic as well as policy-oriented discussions.

A common characteristic of these and other similar visions is that they are elaborated on an a priori basis, i.e., general assumptions about the future based on qualitative assessment of literature and input from the mass media. However, this approach runs the risk of scenarios being developed that are flawed by policy interest or futurists' pre-existing understanding of a topic. In this paper we use a much more inductive approach to exploring scenarios and visions of future urban mobility. Rather than a priori, we take a post-hoc approach to finding the underlying visions operating within a sample of transportation planners, researchers and developers. Our objective is first to establish a general scenario for urban passenger transport in 2050 based on a Delphi study of transport experts, and, second, to explore the potential underlying visions operating within the same sample. As mentioned above, such visions may be seen as pre-elements of scenarios with a connection to ideologies and political orientation.

Given the number and broad constellation of Norwegian transport experts in this sample, it is reasonable to believe that similar latent structures can be found in other countries. These visions may therefore be of relevance on a larger scale than just Norway.

Methodology

A *scenario* can be described as a hypothetical sequence of logical and plausible events put together in a way that draws attention to causal relationships and decision-making anchors [13, 14]. There are several ways that scenarios can be developed. In this study we used the Delphi technique, originally developed in the early 1960s by researchers at the Rand Corporation in the United States and which has since been widely used to develop future scenarios [15].

The methodology is well-established today for developing scenarios and future forecasting, although the popularity of

Delphi studies has fluctuated over the years. In transport research, the technique has been used to develop forecasts for air traffic volumes, public transport, freight and use of electric and uptake of bio-fuel vehicles [16–19]. Some key principles of the Delphi approach are discussed in the next section before we proceed to a description of the research design applied to the study of everyday travel in urban areas in Norway.[1] A *vision*, on the other hand, can be described as a less coherent and structured description of a future state. Visions can be perceived as pre-analytical elements to scenarios, i.e., as sources or preconceptions. Following Heilbroner [20, 21], visions are pre-analytical elements closely connected with underlying political ideologies: "That which we call ideology is therefore perhaps best understood as unrecognized vision, and that which I call vision as consciously embraced ideology" (Heilbroner, 1994, p. 329).

In this paper, we use the term 'visions' to denote latent sets of ideas and attitudes to the future.

Delphi studies – consensus and dissensus

A key idea behind the Delphi method is in achieving a certain degree of consensus around one or more themes aimed at describing the future based on the opinion of selected experts. The methodology can be said to have foundations in the notion that "several brains are better than one", especially in areas with a high degree of complexity and uncertainty [22]. The basic premise of the exercise is that one has access to a group of academic experts with qualified knowledge on topics concerning forecasts. A typical Delphi survey entails the following three steps: (i) the experts are asked to assess a number of possible future visions, statements or projections; (ii) the evaluations of the other experts involved in the survey are cross-checked, and; (iii) the experts have the possibility to modify or correct their initial response. These rounds often call for iterations and in some Delphi studies up to four or five rounds might be involved. Each round of expert ranking leads to either a strengthened consensus or polarized differences.

In most cases, Delphi studies are seen as a *consensus-oriented* technique where experts orient themselves towards a greater or lesser degree of consensus around the key projections or visions of the future within a specific field. It operates on the key principle that the best argument will win, or that the participants will move towards a common understanding. From a theoretical point of view this is supported by Habermasian communication theory, where agreement and common understanding are reached when direct communication is stimulated over time [23]. The usefulness of a *dissensus-based Delphi approach* was outlined as early as 1969 by Turoff with the label Policy Delphi studies [24]. In this version of Delphi, the focus is on exploring different views on the future within a given panel of experts, which could further help to expose divergent views, beliefs or orientations towards the future within a field. Later, this approach was adopted in various studies and projects, including transportation research [25].

An important characteristic of Delphi studies is that respondents provide their *feedback anonymously*, ensuring freedom from the constraints that often lie in formal positions and roles in voicing views and beliefs about the future. Negative aspects of group interactions, such as social pressure and conformity and "halo-effects", are also contained and much of the "noise" related to participation in formal meetings and other fora is assumed to be eliminated or reduced [22, 26]. There are various ways of organizing data collection within Delphi studies to ensure anonymity and carry out iterations. Traditionally, this format was conducted through postal surveys and coordinated by a group of researchers. Delphi studies, thus, have often been considered a relatively time-consuming methodology [22]. In recent years, however, it has become possible to carry Delphi surveys more efficiently through the use of electronic communication media. *Web-based* (*or real-time*) *Delphi surveys* may help panelists get a quicker overview of other participants' responses, thus enabling a quick implementation of iterations [16, 24, 27]. Using a web-based survey also makes it simpler to operate with larger panels.

A key element of almost every Delphi study is the number of statements related to a particular line of development or future situation – *projections* – that the panel is asked to respond to. Input in these projections is often in the form of probability scores or perceived predictive value, or as qualitative data (usually text). Many Delphi studies make a clear distinction between normative and probable projections, as these might be rated very differently, and often normative and expected ratings are collected separately for each projection. Projections may also take the form of being isolated "neutral" descriptions or as elements in a set of pre-defined scenarios, for example explicitly positive and negative developments within a field. This latter approach is suitable in fields characterized by some relatively fixed set of development horizons [28]. Operating with pre-defined visions is usually more relevant in dissensus-based Delphi studies, where support for different images of the future is of key interest.

Research approach

In this study, a central objective was to develop a set of scenarios describing public transport users in central urban areas in Norway in 2050. As discussed above, this is a complex field influenced by a number of factors on different levels. To

[1] For an extensive overview of the Delphi method, cf. Turoff & Linstone (2002), Glenn (2014) and Børjeson et al. (2006).

receive qualified inputs to future scenarios, a web-based real-time Delphi survey was organized.

Most transport scenarios operate with a horizon 15–40 years ahead. The motivation for the relatively long time horizon chosen in this work (35 years) was to open for an unconstrained reflection on future cities not too influenced by current policy issues. Obviously, a longer horizon increases the risk of critical issues being overlooked, incidents and innovations that influence the future. At the same time, our intention was not primarily to give a precise picture of the future, but rather to come to an understanding of the divergent ideas and conceptions driving future development, thus necessitating a longer time horizon.

In addition to the scenarios, we explored latent sets of attitudes and ideas operating within the sample, i.e., what we here call visions. To locate these visions, a principal factor analysis was conducted (as further explained later in the paper).

The project proceeded through five main stages (see Fig. 1). First, projections were elaborated through literature reviews and three internal workshops attended by transport researchers, practitioners and representatives from the transport ministry. A total of 16 projections were eventually constructed within four main themes: use of communication technology; travel behaviour; transport intermodality; and policy measures.

In stage two, a web-based tool was developed based on the analytical MI-pro Research Facility.[2] A real-time Delphi was designed with an interface that recorded quantitative and qualitative responses and provided immediate feedback from other participants before each iteration. The tool was tested in a pilot trial and suitable adjustments were made.

In the third stage, a panel of experts within the field of transport and urban planning was selected through publicly accessible records; for example, a list of transport researchers, political decision-makers, people involved in civic engagement and participants at conferences. Our main idea was to exploit the possibilities embedded in an on-line Delphi and involve a large sample of experts to achieve a wide coverage of beliefs and orientations concerning the future of public transport in urban areas. A thorough examination of accessible lists screened to include individuals with a wide range of expertise ensured that a diverse set of voices could be heard. Of 500 experts, 280 accepted and participated in the survey. No systematic differences were found between those who answered and those who refrained from participating. The survey was distributed to panelists by email during the period 20-12-2014 to 07-01-2015 (more information about the panel is provided in section 2.5).

In stage four, the invitation to take part in the Delphi survey was distributed by e-mail and all the data were structured and analysed in the statistics software SPSS. Based on the information collected from the 280 experts, a factor analysis method was used to explore the underlying response patterns. In the final stage, stage five, these structures were further applied as input to the final scenario and latent visions of future urban public transport.

Our research approach can be described as a dissensus-oriented Delphi, our interest not just in exploring an overall understanding of consensus, but also in the divergent orientations and visions within the panel. This approach resembles what Turoff describes as a Policy Delphi [26], and in recent works this position has been further elaborated by Tapio [25] and Steinert [24]. A common feature of these studies is exploration of opposing views, or dissensus, within a given sample of experts. In this study, we relied on factor analysis to locate a small number of unobserved variables (factors) based on similarities in the responses. These factors are constellations of projections that together describe (more or less) opposing orientations towards the future urban transport system. Since these are not fully elaborated scenarios, but rather divergent political and ideological orientations towards the urban future, we call them "visions", which is in line with the terminology proposed by Heilbroner [21].

From an epistemological point of view, this is an inductive approach where visions are constructed based on empirical investigations rather that pre-analytical categories.

Data collection and development of projections

A *web-based real-time survey* was programmed and applied to capture the interfaces of a real-time Delphi survey. The real-time Delphi design has several advantages over traditional procedures, in particular in relation to efficiency of data collection and in being able to handle larger panels [29]. Compared to most Delphi studies, the panel in our study comprised a large number of participants and our central aim was to collect quantitative data supplemented with qualitative assessments and evaluations.

The interface was set up with two iterations. Panelists could indicate the probability of each projection on a five-point scale. Comments and suggestions could be given as text at two places in the questionnaire. After the first round, the panelists received feedback on the answers given by the other panelists as an average score. Visualisation of recorded answers was presented providing an immediate opportunity for modifications to be made to the answers given in the first round. Records from each round were stored in separate datafiles.

Basic demographic characteristics, industry affiliation, position in employment and academic backgrounds were registered for each participant. Since the Delphi survey was targeted at large urban regions in Norway, the experts were given the opportunity to choose which four cities they could relate to. All projections, however, were identical for all cities.

[2] www.mipro.net

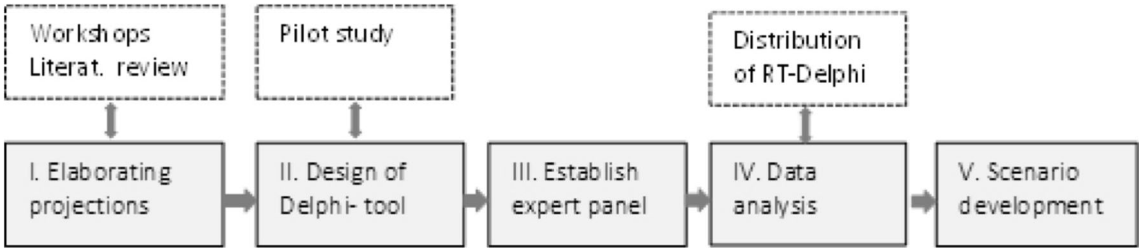

Fig. 1 Steps in the data collection and analysis

The RT-Delphi design was tested in a pilot study involving 23 researchers working in the field of transport and urban planning. We tested key usability factors, the overall design and presentation of the projections, and the ease of comprehension on the iteration process offered to the users. We also received feedback on the projections, which gave us an opportunity to better explore, analyse and structure the data. Several parameters were adjusted after the pilot study (colour choice, manoeuvring buttons) and some projections were changed or corrected.

Review of the literature reveals some of the basic trends and factors which will have significant effects on the development of daily mobility in the future [8, 18]. Key factors include land-use planning, public policies, economic fluctuations, new transport-related technologies and societal/consumer trends. In earlier transport-related Delphi studies these factors have been represented with varying focus [9, 16, 30]. This present study employed an extensive literature review to filter out the first draft list of future scenarios, which in turn were further elaborated and adjusted in two internal workshops with the project-team and a group of public transportation planners. The pilot study also gave significant input to these scenarios.

During the process, it was decided to focus on *four main thematic* areas encompassing future trends: 1) technologies, 2) travel behaviour and commuting, 3) transport intermodality, and 4) policy measures. Four sub-questions were raised concerning each theme, this giving a set of 16 projections (see Table 1), which were intended to be neither positive nor negative but at providing a constellation of relevant issues related to the experience of travelling by public transport in urban areas in 2050. They were formulated as statements and the participants were asked to give ratings of the likelihood of each of them on a five-point Likert scale. In addition to these trend projections, the Delphi survey included an overall assessment of the relative

Table 1 Projections for public transport in Norwegian urban areas 2050

No.	Cat.	Projections
1	TEK	Travellers in urban areas will automatically get suggestions on smartphones for alternative routes based on real-time information and personal preferences.
2	TEK	To a greater extent, people will use their time on public transport to conduct paid work supported by mobile communication technology.
3	TEK	To a greater extent, people will use their time on public transport for amusement and for communicating with friends supported by mobile communication technology.
4	TEK	Use of car-sharing apps to organise private trips will be as common as taxis are today.
5	TB	Increased flexibility in working hours and peak-hour taxes will ensure that all travel connected with work will be evenly distributed throughout the day.
6	TB	Better coordination of bus, train and subway through transport hubs will increase use of public transport facilities in urban areas.
7	TB	A growing number of families will prefer to live in urban city centres to get better access to work, schools and cultural facilities.
8	TB	Development of a knowledge-based workforce and better infrastructure will make long-distance commuting between large cities much more common.
9	IM	City bikes – electric and ordinary – will be used on most personal trips in city centres.
10	IM	The majority of households in large urban areas and adjacent municipalities will not own a private car, but instead rely on car-sharing arrangements.
11	IM	Public transport outside the big cities will be dynamic, based on the real-time needs of people living in the area, and coordinated by mobile communication technologies.
12	IM	Public transport operators will be offering door-to-door transport services.
13	PM	Growth in private car-use will lead to more highways being built between the largest cities.
14	PM	Petrol and diesel driven cars will be forbidden in all city centres.
15	PM	Citizens will have to register all their travel, and will be charged if exceeding an upper limit of CO_2 emissions per year.
16	PM	A growing risk of criminality and terrorism will result in strict security arrangements at all main public transport stations.

(*TEK*, Technology; *TB*, Travel behaviour and commuting; *IM*, Intermodality; *PM*, Policy measures)

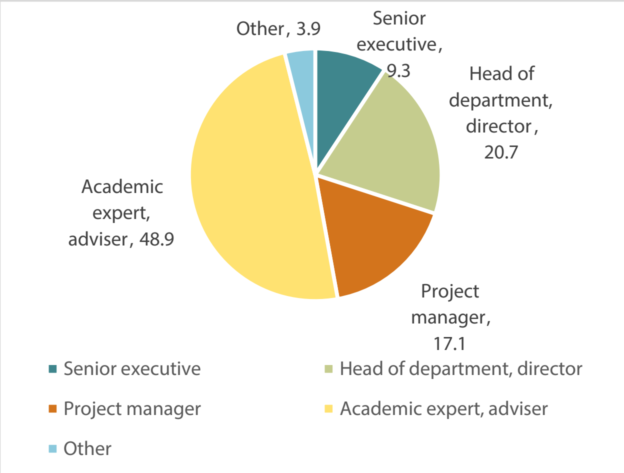

Fig. 2 Expert panel composition. Vocational role (N=280)

shares of various transport modes in future urban regions (private car, public transport, cycling and walking).

Table 3 Adjustments made in the second iteration (N=280)

No.	Projection	Unchanged	Up (%)	Down (%)	Total (%)
1	TEK1	96.4	1.8	1.8	3.6
2	TEK2	95.7	2.1	2.1	4.2
3	TEK3	97.1	2.5	0.4	2.9
4	TEK4	92.1	3.6	4.3	7.9
5	TB 1	96.1	2.2	1.8	4.0
6	TB 2	92.5	3.9	3.6	7.5
7	TB 3	93.2	1.8	5.0	6.8
8	TB 4	94.6	0.7	4.7	5.4
9	IM1	94.3	1.4	4.3	5.7
10	IM2	95.4	1.8	2.9	4.7
11	IM3	91.1	6.1	2.9	9.0
12	IM4	88.9	4.3	6.8	11.1
13	PM1	94.6	3.6	1.8	5.4
14	PM2	94.3	2.5	3.2	5.7
15	PM3	92.9	1.0	6.1	7.1
16	PM4	92.9	2.5	4.6	7.1
	All	93.9	2.6	3.5	6.1

Expert panel and measures

The expert panel in a Delphi study should include well-informed professionals with complementary expertise and insight. Members of the panel in this study were recruited from publicly available records of people with a professional interest in transport planning and urban development. They were individuals who had shown interest in signing up for conferences and seminars, or possessed vocational skills where transport and urban planning were central elements. The invitation to participate as a panelist and all subsequent communication were conducted through e-mail.

The final panel of 280 individuals was comprised largely of professionals employed in the public sector or R&D institutions (including universities). Almost 50 % held an academic position or were professional advisors; about 20 % were department managers or the equivalent; nearly 10 % were senior managers; while a lower share were project managers (Fig. 2). Approximately 60 % of participants were women and the average age was 51 years (s.d.=11.6). The majority had an educational background in urban development/planning, transport planning, social sciences or economics (Table 2).

Table 2 Expert panel composition. Educational background (N=280)

Area of expertise	Percent
Urban development / planning	45.4
Social sciences	36.1
Economy	22.1
Transport technology	16.4
Other	15.0
Environmental studies	12.9
Natural science	11.1
Engineering	7.9
Logistics	6.1
Architechture	3.9
Humanities	3.6
ITS/Informatics	2.9
Demography	2.1
Law	1.8

In sum, the panel consisted of a broad group of professionals extracted from different areas of society, as originally envisaged for the study, yet biased in regard to geographical distribution. The majority knew the Oslo region very well, but few had any insight into the other urban areas (Table 3). The sample was thus biased in relation to place of residence. However, since all projections had a general form unrelated to specific regional issues, we regarded this as a relatively minor problem.

As mentioned above, a primary purpose of Delphi studies is to seek consensus around development trends and themes, and various measures of dispersion are applied to measure degree of consensus. In this study, we used *standard deviation*, probably the most commonly used measure in Delphi studies, supplemented with mode values. Low standard deviation values indicate that the panel gather around mean values and have a high degree of consensus. In tune with similar studies, we define everything below the value of 1.0 as a high degree of consensus within our 5-step Likert scale [31].

The main adjustments were in statements relating to intermodality and political measures, where nearly 11 % of the experts had changed their initial ratings (related to the

Table 4 Overall score for sub-themes

No.	Cat.	Projections	Mean	S.d.	Corr.	Mode
1	TEK	Based on real-time information and personal preferences, travellers in urban areas will automatically receive suggestions for alternative routes on smartphones.	4.4	0.8	3.6	Very likely
2	TEK	To a greater extent, people will use their time on public transport to conduct paid work supported by mobile communication technology.	3.8	1.0	4.2	Somewhat likely
3	TEK	To a greater extent, people will use their time on public transport for amusement and for communicating with friends supported by mobile communication technology.	4.3	0.8	2.9	Very likely
4	TEK	Use of car-sharing apps to organise private trips will be as common as taxis are today.	3.4	1.0	7.9	Somewhat likely
5	TB	Increased flexibility in working hours and peak-hour taxes will mean work-related travel spread throughout the day.	3.8	0.9	4	Likely
6	TB	Better coordination of bus, train and subway through transport hubs will increase use of public transport facilities in urban areas.	4.3	0.8	7.5	Very likely
7	TB	A growing number of families will choose to live in urban city centres to get better access to work, schools and cultural facilities.	3.2	0.9	6.8	Somewhat likely
8	TB	Development of a knowledge-based workforce and better infrastructure will make long-distance commuting between large cities much more common.	3.4	0.9	5.4	Somewhat likely
9	IM	City bikes – electric and ordinary – will be used on most personal trips in city centres.	2.6	0.9	5.7	Somewhat likely
10	IM	The majority of households in large urban areas and adjacent municipalities will not own a private car, but instead rely on car-sharing arrangements.	2.5	0.8	4.7	Somewhat likely
11	IM	Public transport outside the big cities will be dynamic, based on the real-time needs of people living in the area, and coordinated by mobile communication technologies.	3.1	0.9	9	Somewhat likely
12	IM	Public transport operators will offer door-to-door transport services, where other transport modes are included.	2.7	1.0	11.1	Somewhat likely
13	PM	Growth in use of the private car will mean a demand for large highways between the largest cities.	2.6	1.0	5.4	Somewhat likely
14	PM	Petrol and diesel driven cars will be banned in all city centres.	3.3	1.0	5.7	Somewhat likely
15	PM	Citizens will have to register all travel and will be charged for exceeding a given limit of CO_2 emissions per year.	2.3	1.0	7.1	Not likely
16	PM	A growing risk of criminality and terrorism will result in strict security arrangements at all main public transport stations.	2.7	0.9	7.1	Not likely

projection that public transportation companies would provide door-to-door transport).

The frequency of adjustments in the second round is interesting, and we use this as an indicator of uncertainty.[3] A big difference between first and second rounds indicates a high degree of uncertainty related to the particular topic. On average, approximately 6 % of the panel took the opportunity to adjust their assessments in round two (Table 4). There was considerable variation in the various projections, so these can be seen as indicators of thematic areas where the panel were in doubt about what to answer, or how to interpret the future. In the next section, we further discuss the variations in consensus and uncertainties between the projections.

[3] Adjustments in the second round may be an indicator of aspects other than uncertainty. In traditional qualitative Delphi studies, changes in position during the process are often seen as willingness to reconsider a position based on other (better) arguments. As such it can also be seen as an indicator of learning.

Results

We present the results of the panel's assessment in this section – first, the overall scores after one iteration. Results for each theme are presented before we explore the various "orientations" within the panel.

Overall assessment

Technological intervention and its impact on daily mobility surfaces is one of the most influential factors for the future. There was a strong belief that urban passengers would get suggestions for alternative personal transportation routes and connectivity on smartphones/devices based on real-time information and personal preferences.

A large number of the panelists also believed that people would increasingly devote their time on public transport to amusing themselves and communicating with friends using mobile communication technology. The majority of experts rated this projection as “very likely”. The panel had less confidence in the notion that travel time on public transport would be used on paid work, similar to the case for widespread use of carpooling apps organizing private travel. Looking at the scale of corrections, uncertainty was greatest for projections concerning carpooling apps. Yet, the standard deviation indicates that there is a relatively high degree of consensus along all four projections, which means a strong belief that information and communication technologies through smartphones would have a significant impact on daily mobility by 2050.

There was strong consensus on the projections concerning future *travel behaviour*, but still not quite as much as the trends supporting technology intervention. There was a particularly strong belief that better coordination of bus, train and subway routes at major transport hubs/interchanges would contribute to increased use of public transport. Most of the experts considered it “likely” that increased flexibility in the workplace, combined with congestion charges, would help to distribute commuting traffic more evenly over the course of the day. However, the panel was less convinced that increased relocations to inner city areas and growing long-distance commuting between cities would be important parts of reality in 2050. The standard deviation across these projections indicates a relatively high degree of consensus.

The panel was less sure about the projections concerning *transport intermodality* in urban areas, expressed through low probability assessments and involving more corrections. Greatest uncertainty was registered on sub-themes concerning provision of door-to-door services from public transport companies, and a more dynamic public transport service outside city centres. It is interesting that panel members generally believe it “likely” that city-bikes will handle most passenger transport in the inner parts of the city, and that car-sharing arrangements will replace the private car in most families. Low standard deviation scores indicate an overall high degree of consensus in this case as well.

The projections concerning *policy measures* received less support among the expert panel compared to the other themes. In general, very few believed that there would be an individual CO_2 quota or strict security measures at central public transport junctions in Norwegian cities by 2050. A relatively high degree of uncertainty prevails on these issues. It was considered “to some degree likely” that the use of private cars fueled on petrol or diesel would be prohibited in all larger cities. However, projections that highways between the large cities would be expanded – almost a contradictory statement – were also considered as likely, suggesting that the consensus measures cover divergent orientations in the panel.

In sum, there seems to be a high degree of consensus across the 16 projections and only in a few cases does the standard deviation reach a value of 1.0. There is relatively less consensus on policy-related issues where uncertainty is evident. Uncertainty, measured as the number of corrections, is not directly related to differences in average scores. Most uncertainty relates to projections stating that public transport in the future will evolve in the form of door-to-door transport, and that it will be a dynamic and needs-based service provision outside the urban centres (Fig. 3).

The total distribution of statements is visualized in Fig. 4. The overall probability scores (here as mode values) clearly suggest that the technology-related projections receive the greatest support, while statements about intermodality and political conditions are seen as less likely. Some factors in the travel behaviour theme – especially the importance of transport hubs/interchanges for growth in public transport traffic – were also considered as highly probable.

Emergent visions

Overall assessment revealed that contradictory projections were rated with similar likeliness scores, suggesting that there were divergent views on some of them. To investigate further whether there were systematic underlying variations in the panel, an *exploratory factor analysis* was conducted. This is a statistical method used to describe variability among observed, correlated, variables in terms of a potentially lower number of unobserved variables (called factors). Explorative factor analysis is often applied to find out whether there are systematic structures in the material indicating underlying attitudes or orientations [32]. In our case, the factors can be seen as indicators of different visions of the future passenger transport experience in urban areas.

We used a principal component analysis with VARIMAX rotation with Kaizer normalization. The Kayser–Meyer–Olkin index (0.746) and Bartlett’s test (p=0.000) both indicated that the variable correlations were within an acceptable level and appropriate for a factor analysis.[4] The results show how six factors could explain up to 60 % of the variation, three factors nearly 40 %.

The first factor is the most important, explaining more than 20 % of the variation. As indicated in the scree plot, the added value of subsequent factors is limited, in particular 4–16 (Fig. 5). Here, we focus on factors 1–3, which are the most important. The rotated component matrix indicates how each projection has been loaded on the factors (Table 5), the first of which includes a strong belief in the projections suggesting innovative public transport arrangements, combined with strong policy measures to mitigate private car use. Car-sharing and bike-sharing are asserted

[4] The Kaiser-Meyer-Olkin measure of sampling adequacy tests whether the partial correlations among variables are small. Bartlett’s test of sphericity tests whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate.

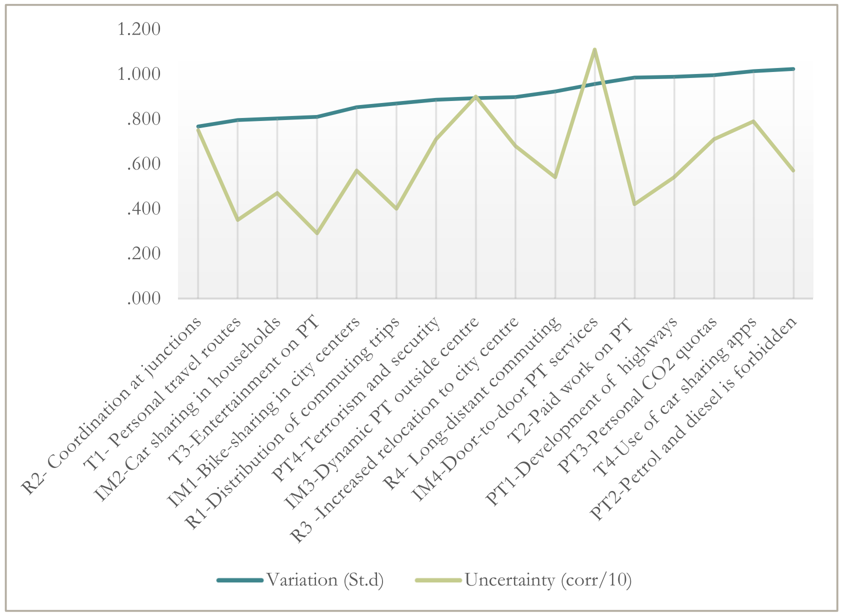

Fig. 3 Variation (s.d.) and uncertainty (corrections after 1 iteration) in all projections. (For full description of the projections, see Table 1)

as important supplementary initiatives. In this component, the likelihood of increased security at transport junctions was seen as high. This, the largest and most important group, possibly expresses general belief in the creation of environmentally friendly urban regions based on public transport in the future.

In the second component, there are projections characterized by technology optimism. There is strong support for the

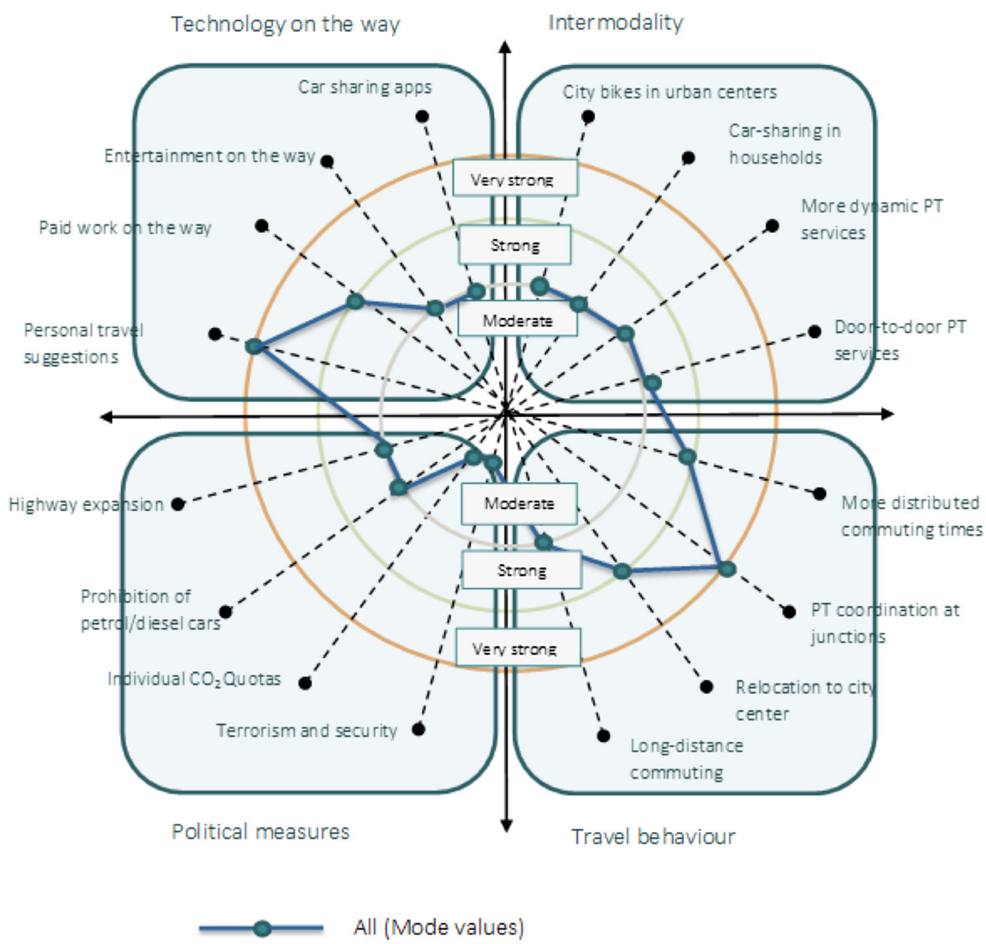

Fig. 4 Overall projection profile for all themes (mode values)

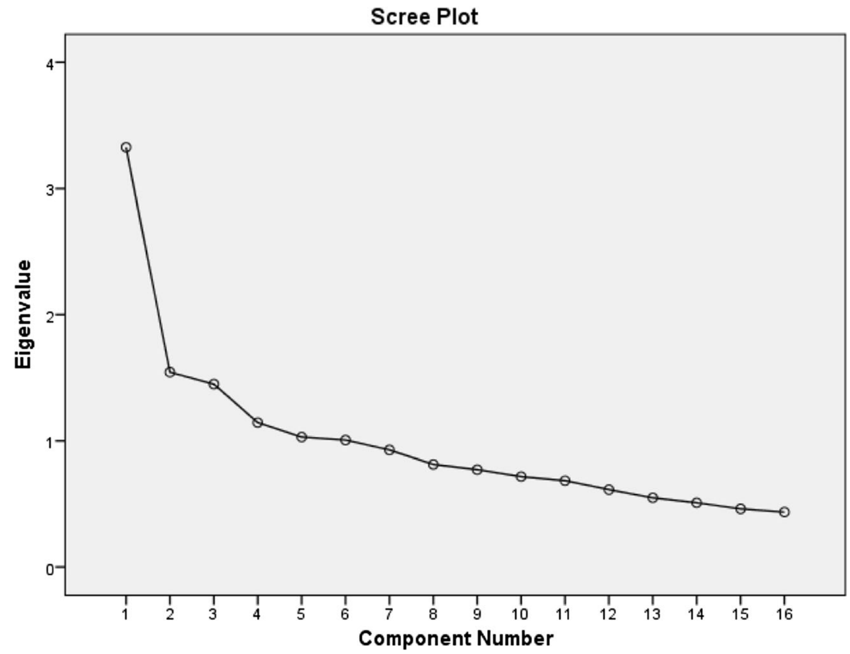

Fig. 5 Scree plot from principal component analysis with VARIMAX rotation

belief that mobile technology will change travel behaviour on public transport modes, as well as the coordination and organization of daily mobility.

In the third component, there is strong support for projections characterized by an environmentally conscious/friendly future, although not backed up by restrictive policy measures. Future urban cities will have a much better public transport system facilitated through efficient public transport hubs and supported by feeder mechanisms such as widespread use of city bikes and car-sharing arrangements. It is assumed that

Table 5 Rotated component matrix. Varimax rotation. (Note: Loadings below 0.3 have been excluded from the table)

	Components		
	1	2	3
Citizens will have to register all their travel, and will be charged if it exceeds a given limit for CO_2 emissions per year.	0.745		
A growing risk of criminality and terrorism will result in strong security arrangements at all the main public transport stations.	0.670		−0.309
Public transport operators will offer door-to-door transport services, forming part of an intermodal chain.	0.592		
Public transport outside the big cities will be dynamic, based on the real-time needs of people living in the area, coordinated by mobile communication technologies.	0.492		
Both petrol and diesel-driven cars will be forbidden in all city centres.	0.464		0.319
Development of a knowledge-based workforce and better infrastructure will make long-distance commuting between large cities much more common.	0.422		
To a greater extent people will use their time on public transport to amusing themselves and communicating with friends, supported by mobile communication technology.		0.722	
To a greater extent people will use their time on public transport to paid work supported by mobile communication technology.		0.712	
Travellers in urban areas will receive automatic suggestions for alternative routes on smartphones based on real-time information and personal preferences.		0.610	
Use of car-sharing apps to organise private trips will be as common as taxis are today.		0.375	
Increased flexibility of working hours and peak-hour taxes will make work travel spread more through the day.		0.369	
Growth in private car use will mean a demand for wider highways between the largest cities.			−0.708
Better coordination of bus, train and subway through transport hubs will increase the use of public transport facilities in urban areas.			0.658
The majority of households in the larger urban areas and adjacent municipalities will not own a private car, but rely instead on car-sharing arrangements.	0.463		0.575
City bikes – electric and ordinary – will be used on most personal trips in city centres.	0.384		0.391
A growing number of families will opt to live in urban city centres to get better access to work, schools and cultural facilities.			

fossil-fueled cars will be excluded from entering inner city areas and the building of roads and highways for cars will not be a priority.

Three visions of future urban passenger travel

Based on explorative factor analysis, three different orientations revealed by the Delphi panel suggest three visions of what urban passenger transport may look like in 2050. We should perhaps underscore once more that this is not an indicator of the desired future, but rather what are seen as the most likely visions. The first and most dominant is of a future in which urban passenger transport will be actively transformed through efficient public transport solutions for all urban citizens. The transition, however, will demand active legislation and taxation to prohibit use of fossil-fueled vehicles and use of individual CO_2 quotas – a "*controlled mobility*" vision of the future urban environment. This approach envisages a city region controlled by a political authority where terrorism and criminality are more widespread, and demanding strong security measures at transport hubs. There is thus the hint of a more dystopian development in this dominant vision, a vision that comes close to what Urry and others have described as a "controlled mobility future" [33]. There are some interesting paradoxes, however. While on the one hand it describes strong measures to curb use of private cars in cities, on the other hand long-distance commuting between large cities will become more widespread. The controlled mobility vision is in many ways a continuation of policies today, where transformation to more eco-friendly transport is combined with a rapidly growing globalization of passenger transport and freight.

The second vision is of a techno-optimistic outlook on the impact of new mobile technologies which will radically transform travel behaviour by offering immediate real-time information and suggestions for optimal travel routes based on former behaviour. Concerns about privacy issues do not seem to be of high importance in this scenario owing to the advantages of individualized information and control. Information technology will play an active role through travel apps and other technologies to coordinate shared transport resources in the inner city. Active use of travel time on public transport through a combination of communication, work and play forms part of this vision. Moreover, increased flexibility in work, along with congestion charging schemes, will make peak hour traffic less problematic in the future. In many ways this vision reflects what the future scenario ecologist Peter Sale has labelled "*Technopolis*", characterized by a growing technology addiction but also progressively more fragmented and distanced communities [7]. Efficiency given priority over individual privacy is an indication that this vison may be close to "Controlled mobility", although with a more techno-optimistic accentuation.

The third vision outlines an eco-friendly urban future where shared resources and a more efficient transport system leave little room for private vehicles. Car-sharing will be the norm for most families in urban regions. This vision may therefore be labelled "*Shared mobility*", according to which the green city will evolve mainly from civic engagement and a common understanding of the necessity of more sustainable transport solutions, and not strictly from strong policy measures. Long-distance commuting and globalization in this vision become replaced by more locally embedded activities demanding much more concentrated urban development. This vision then bears some similarities to what Dennis and Urry describe as "Local sustainability" and other visions that emphasize the transformation to a more community oriented, self-sufficient, society [12].

Discussion and conclusions

The results presented in this study are based on findings from an online, real-time Delphi (RT) survey. This is a relatively new way of collecting data for a Delphi study, and although it provides researchers with benefits in relation to rapid access to a wide number of contributors, it has certain limitations [29, 34], in particular relating to reduced opportunities for discussion and communication between partners. Admittedly, this undermines some of the consensus-oriented focus prevalent in most traditional Delphi studies. The quantitative format of most RT Delphi's makes it more difficult to reach "common ground" based on reciprocal exchange and evaluation of arguments. In this study, more extensive use of qualitative data could perhaps have ensured more interactive communication, although this would obviously have required a more extensive design. Second, although the RT Delphi opens up for a much larger number of contributors, the effect of a large panel can also be hard to describe precisely. On the one hand, it gives voice to a broad variety of interests rather than a small group of pre-defined "experts", and can therefore be seen as more democratic and inclusive. On the other hand, however, the representativeness and potential bias of the panel is hard to estimate. Despite these shortcomings, we believe that the scenarios derived from this study qualify as suitable grounds for discussion on looking and planning ahead.

The need for scenario planning is based on an intrinsic failure of transport modelling exercises to capture the nuances of travel behaviour and predict future scenarios. These nuances need to be inserted in creating alternative future scenarios. Issues concerning the future of public transport provision, for example ageing, urbanisation and the preferences of current public transport users, form integral parts of planning for future public transport. Their importance is also highlighted in studies focusing on the uncertain future of travel demand [4]. Empirical evidence from many developed countries shows that below the aggregate data younger men and others in urban areas are travelling less by car, while women and others in less densely populated areas are travelling more by car [4, 35–37]. This suggests that coming decades may witness other choices and preferences regarding urban mobility. Technologies (in particular mobile ICTs) are fast changing the landscape of both travel demand and behaviour. Lyons [38] has taken this further in examining the hypothesis that something even more fundamental is happening – namely that society is in transition from the regime of automobility into something else as the 'motor age and the digital age collide'. Transition is coming about by the permeation of an increasing number of digital age technology advances and capabilities into social practices and everyday lives and norms.

Similar to the case of predicting future travel behaviour through transport models, filtering out the influences of digital age advances (which have still not been introduced to the market) and practices on daily mobility owing to the complex mix of technologies and travel relationships remains a challenge [39–41]. This study has explored some visions of how the future urban landscape will look according to a large and heterogeneous sample of transport planners and experts.

Given the format of the study, with a limited number of projections, the visions outlined necessarily have a simplistic form. More research needs to be carried out if we are to fully understand the interactions between a "Controlled Mobility" future, an emerging "Technopolis" and a "Shared Mobility" society with special reference to the following: (i) Individualised versus collective transport – what motorised modal preferences will people have? What kind of public transport provision will best meet the needs of future urban areas in Norway? (ii) Engagement in active travel – will walking and cycling resonate with the theme of an ageing society, adverse climatic conditions and acceptance of such modal shifts? How can walking and cycling and schemes like car-sharing be developed as feeder mechanisms to the main public transport supply? (iii) Types of journey being made – why will people be travelling? Will work-related trips evolve into a different format evenly spread throughout the day? (iv) Journey substitution through technology – will people embrace forms of social participation other than those reliant on personal mobility? The visions explored in this study could be used as points of departure in different scenarios for understanding and detailing future urban transport systems.

Follow-up studies in this area will confirm whether the visions located here are representative of samples and cases across other regions and countries. It would be of interest to develop better insight into how these, and similar visions, are reflected in public discussions and policy documents concerning future urban transportation systems. A better understanding of the existence of emergent visions of the urban future has the potential to shed light on how scenario-building is related to pre-existing attitudes, ideas and ideologies. Delphi techniques have much to offer here, and this study has only just begun to scratch the surface of this important field.

Acknowledgments This paper has been published with grants from the Norwegian Research Council and the Norwegian Ministry of Transport and Communication.

The dataset used in this study can be made available for further scientific analysis on request to the authors.

References

1. Behrens R (2000) Activity-travel analysis: A review of theoretical origins, recent developments and local application. In South African Transport Conference, A.i.T.f.t.N. Millennium., ed. (Pretoria)
2. Arentze TA, Timmermans HJP (2007) Robust approach to modeling choice of locations in daily activity sequences. Transp Res Rec 2003:59–63
3. Bowman JL (1998) The day activity schedule approach to travel demand analysis. Volume Ph.D. Massachusetts Institute of Technology, Cambridge
4. Shergold I, Lyons G, Hubers C (2014) Future mobility in an ageing society - Where are we heading? J Transport Health
5. Hubers C, Lyons G (2013) Assessing future travel demand - a need to account for non-transport technologies? Foresight 15:211–227
6. Hubers C, Lyons G (2013) New technologies for the old: potential implications of living in later life for travel demand. Transp Policy 30:220–228
7. Baer HA (2012) Global Capitalism and Climate Change: The Need for an Alternative World System, (Alta Mira Press)
8. Hoppe M, Christ A, Castro A, Winter M, Seppänen T-M (2014) Transformations in transportation? Eur J Futures Res 2:2–45
9. Hickman R, Saxena S, Banister D, Ashiru O (2012) Examining transport futures with scenario analysis and MCA. Transp Res A 46:560–575
10. Bristow A, Pridmore M, May A (2008) Developing pathways tolow carbon land-based passenger transport in Great Britain in 2050. Energy Policy 36:3427–3435
11. Marletto G (2014) Car and the city: Socio-technical transition pathways to 2030. Technol Forecasting Social Change 87:264–278
12. Dennis K, Urry J (2009) After the car. Polity Press, Cambridge
13. Kahn J, Wiener AJ (1967) The Year 2000: A Framework for Speculationof the Next 33 Years, (New York)
14. Linstone HA, Turoff M (1975) The Delphi Method - Techniques and Applications, (Addison-Wesley Publishing Company Inc.)
15. Glenn JC (2014) Introduction to the futures research method series. In Volume 3 Edition, T.M. Project, ed
16. Schuckmann SW, Gnatzy T, Darkow I-L, Gracht HA (2012) Analysis of factors influencing the development of transport infrastructure until the year 2030 - A Delphi based scenario study. Technol Forecasting 79:1373–1387
17. Højer M (1997) Telematics in urban transport - a Delphi study using scenarios. Volume FR 97–23. Royal Institute of Technology, Stockholm
18. Nijkamp P, Rienstra S, Vleugel J (1998) Transportation Planing and the Future. Wiley, Chichester

19. Shiftan Y, Kaplan S, Hakkert S (2003) Scenario building as a tool for planning a sustainable transport system. Transp Res D 8:323–342
20. Heilbroner R (1990) Analysis and Vision in the History of Modern Economic Thought. J Econ Lit 28:1097–1114
21. Heilbroner R (1994) Vision in Economic Thought. J Econ Issues 28:325–329
22. Chia-Chen H, Sanford B (2007) Tle Delphi Technique: Making Sense of Consensus. Pract Assesment Res Evac 12
23. Habermas J (1984) The Theory of Communicative Action. Volume One: Reason and the Rationalization of Society. Beacon Press, Boston
24. Steinert M (2009) A dissensus based online Delphi approach: An explorative research tool. Technol Forecast Soc Chang 76:291–300
25. Tapio P (2002) Disaggregative policy Delphi Using cluster analysis as a tool for systematic scenario formation. Technol Forecast Soc Chang 70:83–101
26. Turoff M, Linstone HA (2002) The Delphi Method: Techniques and Applications (New Jersey)
27. Gill FJ, Leslie GD, Grech C, Latour JM (2013) Using a web-based survey tool to undertake a Delphi study: Application for nurse education research. Nurse Education Today 33
28. Børjeson L, Höjer M, Dreborg K-H, Ekvall T, Finnveden G (2006) Scenario types and techniques: Towards a user's guide. Futures 38:723–739
29. Gordon T, Pease A (2006) RT Delphi: An efficient, "round-less" almost real ime Delphi method. Technol Forecasting & Social Change 73:467–482
30. Shiftan Y, Kaplan S, Hakkert S (2003) Scenario building as a tool for planning a sustainable transportation system. Transportation part D 8:323–342
31. Gracht HAvd (2012) Consensus measurements in Delphi studies. Review and implications for future quality assurance. Technol Forecasting ans Social Change 79
32. Johnson RA, Wichern DW (1992) Applied Multivariate Statistical Analysis. Prentice-Halls, Englewood Cliffs
33. Urry J (2007) Mobilities. Polity, Cambridge
34. Gnatzy T, Warth J, Gracht H, Darkow I-L (2011) Validating an innovative real-time Delphi approach - A methodological comparison between real-time and conventional Delphi studies. Technol Forecasting Social Change 78(2011):1681–1694
35. Vine SL, Jones P (2012) On the Move: Making Sense of Car and Train Travel Trends in Britain. RAC Foundation, London
36. Stokes G (2013) The prospects for future levels of car access and use. Transp Rev 33:360–375
37. Goodwin P, Dender KV (2013) Peak Car' - themes and issues. Transp Rev 33:243–254
38. Lyons G (2015) Transport's Digital Age Transition. J Transport Land Use Article In Press
39. Mokhtarian P (2003) Telecommunications and travel: the case for complementarity. J Ind Ecol 6:43–57
40. Mokhtarian P (2009) If telecommunication is such a good substitute for travel, why does congestion continue to get worse? Transp Lett 1:1–17
41. Aguiléra A, Guillot C, Rallet A (2012) Mobile ICT and physical mobility: Review and reearch agenda. Transp Res A 46:664–672