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Sustainable management at a public transport provider – from large scale scenarios to small-scale decisions

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Sustainable management at a public transport provider – from large-scale scenarios to small-scale decisions[1]

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Summary

The transport sector tackles one of the most important tasks for social life: to transport people and goods. Transport affects its environment significantly (e. g. by CO_2-emissions), being itself highly exposed to and affected by future changes such as climate or demographic change. To ensure a sustainable developed transport, decision-makers from both policy and organizations have to assess future challenges, develop possible futures, and derive sustainably decisions. While research focuses on scenario development for transport on large scales, the actual transfer to small scales remains unexplored. Aiming to fill this research gap, we apply scenario planning within a case study at a public transport provider. Thereby, we answer two major research questions: (1) What future challenges shape decision-making at a public transport provider? and (2) How can large-scale scenarios (possible futures) be transferred to small-scale sustainable decision-making? Given a desirable future ("multi-modal cooperation", one of four scenarios), strategies towards a sustainable full service provider were developed.

Introduction

To ensure their success, organizations have to consider current and future developments and changes that might shape their businesses. One of the major changes and challenges is climate change, given the variety of direct and indirect impacts (e. g. extreme weather events or environmental regulations). Its relevance and influence can be illustrated by the example of the (public) transport sector, where climate change demonstrates a mutual link of effect.

Chapman (2007) states: "Transport accounts for 26 % of global CO_2 emissions and is one of the few industrial sectors where emissions are still growing" (Chapman, 2007, p. 354). This fact is caused by transport's dependence on fossil fuels (Chapman, 2007) and is confirmed by various studies or reports. According to Hickman et al. (2010), the "transport sector contributes around 25 % carbon dioxide (CO_2) emissions in the UK, yet remains the major underperforming sector in contributing to emissions reductions" (Hickman, Ashiru, & Banister, 2010, p. 110). Or, as the IPCC (2007) confirms, the

1 The authors kindly want to thank the German Federal Ministry of Education and Research, which financed the project for climate change adaptation, within this study was conducted. Especially, the authors want to thank the case public transport provider for the good cooperation and great support.

growth rate of emissions by the transport sector is "highest among the end-user sectors" (IPCC, 2007, p. 325). Given this state and the relevance of the transport sector ("Human survival and societal interaction depend on the ability to move people and goods", IPCC, 2007, p. 328) it is no surprise that high priority has to be put in the development of "environmentally sustainable transport" (OECD, 2000).

This endeavor requires major efforts. Based on current states, the assessment and analysis of impacts and trends as well as links of effects frame the development of possible futures, visions, and strategies for sustainable transport and mobility (e. g. Institut für Mobilitätsforschung (ifmo), 2003; IPCC, 2007; OECD, 2000). These global and large scale applications are considered the origin for transfer to smaller scales (e. g. McCollum & Yang, 2009; Vergragt & Brown, 2007). Therefore, technological requirements (e. g. alternative (bio)fuels) that enable the implementation of these strategies have to be provided (e. g. Bright & Strømman, 2010; Winebrake & Creswick, 2003).

However, the other direction of effect has to be considered too: the impacts of climate change on (public) transport. Especially extreme weather events such as floods have major direct impacts on infrastructure and road safety (Koetse & Rietveld, 2009). The impacts of climate change do not necessarily have to be negative, such as a positive effect on tourism in warmer summers proves (Hamilton, Maddison, & Tol, 2005; Koetse & Rietveld, 2009). To deal with direct (as well as indirect) impacts of climate change addresses the climate change adaptation aspect. But also indirect impacts have to be considered, such as the increase of procurement costs by higher resource and energy prices (Stern, 2006) or higher pressure by economic climate policy instruments (e. g. fuel taxes), mainly addressing the climate change mitigation aspect (Sterner, 2007).

Additionally, organizations are affected by a vast array of influences, depending substantially on their business fields (Fassin, 2009; Freeman, 1984; Porter, 2008). This becomes particularly obvious in the (public) transport sector, which is highly sensitive to future changes such as technological or demographic change due to the necessary long-term infrastructure investments (Holmgren, 2007), on the one hand, and volatile customer behavior, on the other (e. g. Bresson, Dargay, Madre, & Pirotte, 2003; Holmgren, 2007; Oosterhaven & Knaap, 2003). Thus, to assess and integrate long-term challenges into decision-making on a small scale is crucial, i. e. the organizational level.

When companies or organizations seek to think strategically and for the long-term, scenario planning is a suitable and often used method. Scenarios provide different possible futures, stimulate thinking about variants and alternatives, and allow the companies to make appropriate and sustainable decisions regarding future changes and challenges (Mietzner & Reger, 2005)[2]. Or, as Chermack et al. (2001) highlight,

2 We refer to Mietzner and Reger (2005) for a summary of definitions and characteristics of "scenario in research literature.

"Scenario planning encourages organizational leaders to think the unthinkable" (Chermack, Lynham & Ruona, 2001, p. 7), in order to be prepared for the future.

As will be shown in the background section below, due to the application of scenario planning in different fields, a variety of scenario methods and techniques have evolved over the years (e. g. Bradfield, Wright, Burt, Cairns, & van der Heijden, 2005) (while highlighting the current problem, Martelli (2001) calls it "methodological chaos", such as classic methods like Cross Impact Analysis (Gordon & Hayward, 1968) or innovative tools like Fuzzy Cognitive Maps (e. g. Jetter & Schweinfort, 2011; Kok, 2009).

Thereby, scenario planning is widely used in the transport and mobility context. Von der Gracht & Darkow (2010) apply the Delphi method to develop scenarios for the logistics industry in Germany. They integrated 30 CEOs and strategy experts to identify and discuss future developments in the micro- and macro-environment of the logistics services industry and, with this basis, developed projections until 2025 (von der Gracht & Darkow, 2010). O' Brien and Meadows (2013) apply scenario planning within a strategy exercise at an organization in the UK transport sector. Their case study analyzes how scenarios can be used and transferred within strategic planning processes on the small-scale organizational level (O'Brien & Meadows, 2013).

However, reviewing the state of the art in research (to be seen in a later section) clear cognitions can be taken. Most of the studies in the area of scenario planning for transport and mobility focus on large scales, i.e the global or national level. Only a few cover a medium-scaled focus, i. e. on the urban/local level. Finally, only 3 (case) studies could be identified that show a clear focus on the decision-making level and cover the development and transfer of small-scale scenarios into small-scale sustainable decision making, i. e. the organizational decision level. This states a major research gap for applications/case studies that analyze the use and transfer of large- (or medium-)scale scenarios to small-scale decision-making.

Thus, aiming to fill the research gap, the objective of our study is to analyze how *large-scale scenarios are transferred to small-scale decisions*. Therefore, we define two major research questions:

1. What future challenges shape decision-making at a public transport provider?
2. How can large-scale scenarios (possible futures) be transferred to sustainable decision-making on the small scale?

To answer our research question we use the approach by Yin (2009) and to conduct a case study at a public transport provider. Thus, we contribute to the literature by providing a methodological approach for the use and transfer of large-scale scenarios to small-scale decision-making. Furthermore, we contribute to practice by providing a best practice example for the use of scenario planning and integration of long-term thinking into decision-making.

Our paper is organized as follows: First, we introduce a short theoretical background on scenario planning. The findings of a literature review present the state of the art of

scenario planning in the transport and mobility sector. Following a description of our methodology we outline our results of the scenario planning application at a public transport provider. We close with a reflection and discussion.

Theoretical Background

Scenarios have been used in various fields of application, such as in military war plans. Modern scenario planning goes back to the work of Herman Kahn, who developed scenarios at the RAND cooperation in the 1950s for American missile defense. Pierre Wack refined his approach and applied it successfully in the business sector at Royal Dutch Shell (Bradfield et al., 2005; van der Heijden, Bradfield, Burt, Cairns, & Wright, 2002; Wack, 1985).

Scenario planning cannot predict the exact future, scenarios are rather "a description of a possible future situation (conceptual future), including paths of development which may lead to that future situation" (Kosow & Gaßner, 2008 (referring to other authors), p. 11). Future challenges are identified and options for adaptation are derived. Thus, scenario planning supports the ability to "think the unthinkable" (Chermack et al., 2001, p. 7). Complex coherences can be presented clearly and the participation with stakeholders eased.

Its popularity and the extensive application of scenario planning in various fields have produced a variety of different techniques and approaches (Bradfield et al., 2005; Varum & Melo, 2010). However, over time a "methodological chaos" (Martelli, 2001) has evolved concerning the different methods and techniques. Given this situation and the demand for mainstreaming (Bishop, Hines, & Collins, 2007; Millett, 2003), many researchers have provided overviews and typologies of the evolution and classification of different scenario techniques (as described in Nowack & Guenther, 2010; Nowack, Endrikat, & Guenther, 2011, e.g. van Notten, Rotmans, van Asselt, & Rothman, 2003, Bradfield et al., 2005, Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006, Bishop et al., 2007, and Varum & Melo, 2010). However, a consensus on the origins and major pillars of scenario planning does exist. The approach of Bradfield et al. (2005) is remarkable because it depicts the different ways in which scenario planning has evolved since its origins at the RAND Corporation and integrates a typology of scenario techniques, distinguishing the "intuitive logics school", "trend-impact analysis" (TIA), and "cross-impact analysis" (CIA), as well as "la prospective school" belonging to the French research strand. They extended the already existing classification of Huss & Honton (1987). The intuitive logics school was developed in the 1970s through the application of the scenario method at Royal Dutch Shell by Wack (1985). Based on that application, a variety of scenario approaches were created as a result of the different practical applications of that approach (Bradfield et al., 2005). A more probabilistic approach to scenario planning developed within the fields of TIA and CIA, concerning the extrapolation of historical data including unpreceden-

ted future events and analyzing their probabilities of occurring (Bradfield et al., 2005; Gordon, 1994a; Gordon, 1994b). The typology concludes with "la prospective school", a branch of scenario planning that evolved in France in the 1970s through the efforts of Godet (Godet, 1986; Godet, 1987; Godet, 2000), which also follows a more probabilistic approach and is heavily focused on computer-based mathematical models (Bradfield et al., 2005). In contrast, Börjeson et al. (2006) orientate their typology with respect to the needs of scenario users and classify scenarios into three types, based on the type of question at hand; predictive scenarios (what will happen?), explorative scenarios (what can happen?), and normative scenarios (how can a specific target be reached?). Bishop et al. (2007) provide a representation and comparison of other typologies and define eight different categories that they use to situate different scenario techniques.

State of the art

To comprise the current state of the art of research in the field of scenario analysis in transportation and mobility, we conducted a literature review following the principle of Fink (2010). Therefore, our research question of the review is the following: How is the scenario method used in the transport and mobility sector, especially in the public transport sector? Specifically, we wanted to identify if and how scenario planning is applied at the large- and small-scale. Finally, a clear focus was on the identification of ecological impacts on the transport and especially public transport sector. As major search terms we used scenario analysis (develop*, planning, technique, method and building), transport (public transport, traffic, transit), and mobility. As databases, the library services EBSCO Host (Academic Search Complete, Business Source Complete, EconLit with full text, E-Journals, Risk Management Reference Center, TOC Premier) and Web of Science were used. As our case study has its spatial focus on Germany, we used German search terms and searched in German databases WISO and TEMA, too. Furthermore, we had access to the internal publication database Mobi+ of the International Association of Public Transport (UITP). As our objective was to draw conclusions on our case study, we decided to ensure the currentness of the state of the art by excluding publications before 2000.

Through the review of the titles and abstracts, 157 publications were identified as relevant. Sources that rely on the same scenario project were reduced to the original source. Furthermore, publications that do not clearly focus on mobility or transport were excluded. Finally, the sources were checked for the content of the method. If there was insufficient information on scenario analysis included, the studies were excluded, too. Thus, in total a number of 77 studies remained. In a detailed overview that can be seen in the Annex, we categorize the results according to our review research questions as follows: authors, year of publication, focus of the study, region/scale, time horizon of scenarios, ecologic influences on transport, challenges for public transport. The latter two categories are a main focus in the results section. In

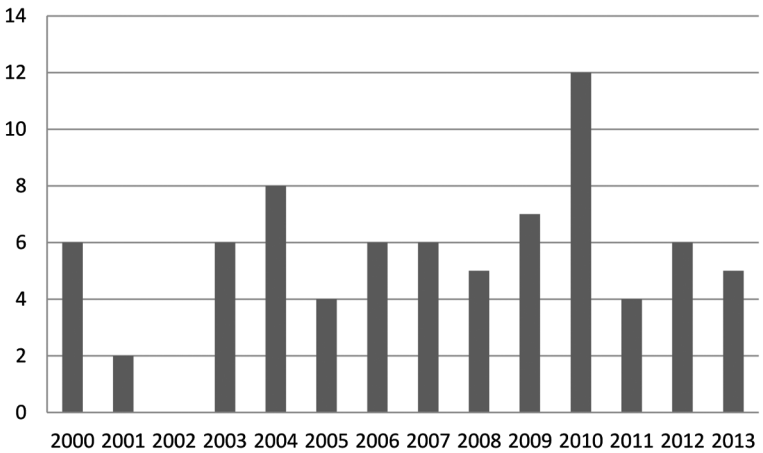

Figure 1: Publications per year

the following we will present and comment on the state of the art in research on scenario planning in the field of transport and mobility.

Figure 1 shows the distribution of the publications over the years. No significant trend can be seen in that development.

As time horizons for the development of futures, the year 2030 (25 times) is preferred, but also 2020 (13 times) or 2050 (12 times) are chosen. Ultra-long scenarios exist with a time horizon of 2100 (5 times).

Analyzing the focus of the studies, sustainability can be identified as the main driving force for analysis (more than 20 studies), which highlights the relevance of climate change impacts compared to other influences. In the majority of these studies, futures for a sustainable transport or mobility are developed (e. g. Akerman & Hojer, 2006; Ceron & Dubois, 2007). Often specific goals (e. g. for reduction of CO_2 emissions) for a certain time horizon (e. g. 2050) are defined and then measures are identified to reach those goals (e. g. Banister, Dreborg, Hedberg, Hunhammar, Steen, & Akerman, 2000). In close relation to the focus on sustainability, a great number of scenario studies analyze new drive or fuel technologies (12 studies, e. g. Bright & Strømman, 2010; Winebrake & Creswick, 2003) that might contribute to a future sustainable transport or mobility. Other fields are logistics and freight transport (e. g. Piecyk & McKinnon, 2010; von der Gracht & Darkow, 2010), tourism (e. g. Ceron & Dubois, 2007), or mobility in general (e. g. Institut für Mobilitätsforschung (ifmo), 2003).

Finally, a closer examination of the studies' scales provide interesting findings (see the table in the Annex for the individual results). The majority of studies are focusing on a large scale. Thereby, 25 studies focus on a global/international level (e. g. Europe). 32 studies restrict to the national level. In total, 57 studies focus on large scales, repre-

senting 74 % of the state of the art. On the other hand, 12 studies look at the urban/local level and thus we assigned them to medium-scale studies (while for 5 studies the scale could not be specified). Thereby, some of these studies consider the use of scenarios for strategic planning and derive strategy options for (spatial) transport planning (e.g. Bracher & Diekelmann, 2004; Hickman, Saxena, Banister & Ashiru, 2012). However, only 3 studies, 4 % of the state of the art, could be identified that focus on the smallest scale, the decision-making level in organizations. These are case studies that analyze the development and transfer of small-scale scenarios into decision-making in organizations. (Andersen, Lundli, Holden, & Høyer, 2004; O'Brien & Meadows, 2013; Page, Yeoman, & Greenwood, 2009).

Studies, e. g. by the OECD (2000) or the WBCSD (2004), seek to assess on a global and thus large-scale impacts of transport or individual mobility (behavior) and trends for future developments in order to develop both visions for a sustainable transport/mobility and strategy derivations on how to achieve this state. Various studies and projects follow this approach on national or regional areas (e. g. Institut für Mobilitätsforschung (ifmo), 2003 or Hickman et al., 2012).

As example for a case study, Andersen et al. (2004) present by means of the case company Oslo Sporveier (central public transport provider in Oslo) small-scale (city level) scenarios for person transport in 2016. The corporate strategy built the framework for e. g. a public transport scenario (one within others). By predicting energy use and emissions, important input for environmental reporting is gathered (Andersen et al., 2004).

Page et al. (2009) analyze the scenario planning process at VisitScotland, the lead organization for tourism in Scotland. With the vision to increase the value of Scottish tourism by 50 % (by 2015), the case organization seeks to analyze their small-scale business environment and future trends in order to increase their competitiveness (Page et al., 2009).

O'Brien and Meadows (2013) analyze the transfer of developed small-scale scenarios. Thereby, an exercise (experiment) for strategy development was conducted with senior managers of a major organization of the UK transport sector. A critical reflection of their observations provides interesting insights regarding the use of scenarios in strategy development (O'Brien & Meadows, 2013).

To summarize, we can draw some major conclusions. On the one hand, given its (economic and social) relevance, the transport and mobility sector is a highly relevant and central research area concerning (global) sustainable development in accordance with climate change and other future challenges. However, the focus of attention mainly remains on large scales. Medium scales are often represented in urban or local applications/studies. On the other hand, one can clearly identify a major research gap in the use and transfer of large-scale visions and scenarios to small-scale decision-making, as this field of research is highly underrepresented in the state of the art but required by practice.

Aiming to contribute to this research gap, the following methodology section will lay out our approach before we present our results.

Methodology

Case study

Case studies are a popular application in the field of social science to explain contemporary events or phenomena, usually combining data collection methods focusing on single or multiple cases (Eisenhardt, 1989; Yin, 2009). According to Yin (2009), the scope of case studies can be defined as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p. 18). Case studies allow the combination of both qualitative and quantitative data and are used – besides other aims – for presentation (e.g. as best practice examples) (Eisenhardt, 1989).

Given these conditions we identified the case study methodology as appropriate for our study aiming to answer our main research questions: (1) What future challenges shape decision-making at a public transport provider? and (2) How can large-scale scenarios (possible futures) be transferred to sustainable decision-making on the small scale?

Therefore, we follow the approach of Yin (2009), one of the most recognized in social science. He proposes five components of an initial research design (study's questions, its propositions, unit of analysis, logic linking the data to the propositions, criteria for interpreting the findings).

Our case study analyzes a contemporary phenomenon. In times of increasing challenges for businesses, long-term thinking and strategic planning (mainly in smaller organizations or companies) is still not fully integrated in a decision-maker's repertoire (Burt & van der Heijden, 2003; Frost, 2003; Johnston, Gilmore, & Carson, 2008; Will, 2008). Especially the relationship between current states and future developments of challenges for businesses has to be considered. Rather, our main focus is to analyze how large-scale scenarios can be transferred into small-scale sustainable decision-making.

Study's questions

Two main research questions frame our study:

1. What future challenges shape decision-making at a public transport provider?
   a. How do environmental aspects and climate change (derived from large scales) affect the business?
   b. In total, what influences affect the business?
   c. What are key challenges and how are they interrelated?
   d. How can possible futures for the public transport provider look like?

2. How can large-scale scenarios (possible futures) be transferred to small-scale sustainable decision-making?
   a. What consequences are derived from small-scale scenarios for small-scale sustainable decision-making?
   b. Which strategies can be developed for small-scale sustainable decision-making?
   c. How can small-scale strategies be transferred into small-scale sustainable decision-making?

Study's propositions

According to Yin (2009), propositions are essential for a case study: "Only if you are forced to state some propositions will you move in the right direction" (Yin, 2009, p. 28).

Our propositions are that
- there is a great variety of different future challenges for a public transport provider,
- strong interrelationships within future challenges exist, and
- strategic planning is crucial in the implementation of appropriate action.

Unit of analysis

The definition of the unit of analysis is strongly dependent on the developed research questions and, thus, is essential in the defining of the limits of the case (Yin, 2009). Our unit of analysis is an organization in the public transport sector. Practically, we are focusing on the business management and business strategy and development department within the organization.

Linking data to propositions and criteria for interpreting the findings

Yin (2009) himself mentions that "the current state of the art does not provide detailed guidance on the last two …" (Yin, 2009, p. 34). However, during the research design phase it is crucial to already consider how to combine the collected data to the initial propositions (e. g. by pattern matching or logic models) and how to evaluate the findings by being aware of "rival explanations" (Yin, 2009, p. 34).

In our case study we use different methods to gain data and to reflect the results towards our propositions. The scenario method creates the framework for our analysis and is assisted by Fuzzy Cognitive Maps (FCM).

Furthermore, Yin (2009) suggests following a case study protocol for the analysis. The protocol should cover an overview of the study, field procedures, questions that have to be kept in mind during the data collection, as well as a guide for a case study report (Yin, 2009). In the next step we will follow this principle and describe our actual methodological procedure (overview and field procedures) before presenting our findings.

Actual methodological application

Overview of the study

The objective of the case study is to answer our research questions by first assessing and evaluating future challenges for the business of a public transport provider for the year 2030 and second, to develop and transfer large-scale scenarios into small-scale sustainable development. Within an iterative scenario process, gradually our (sub-) research questions are answered.

Public transportation is highly sensitive to future changes due to the necessary long-term infrastructure investments (Holmgren, 2007), on the one hand, and volatile customer behavior, on the other (e. g. Bresson et al., 2003; Holmgren, 2007; Oosterhaven & Knaap, 2003). Therefore, it offers the appropriate conditions for the analysis of our propositions. Rather, the organization itself is highly interested in analyzing future challenges for their business and developing appropriate strategies. The selected public transport provider is an incorporated organization, of which the city holds 100 percent of the shares. Thus, its dependence on the city's regulations is vital. In addition to the classical task of providing public transportation, additional services (e. g., traffic services, travel agency services, IT services) are provided by subsidiaries.

Contact and cooperation partners at the case organization are two CEOs and the director of the head office, all of whom deal with corporate strategic planning.

Field procedures

The practical field procedure consists of a mix between (scientific) desk research as well as data collection and iterative analysis on site (by workshops and discussions). We use scenario planning as the main methodological framework for our study.

There exists a variety of different scenario approaches, differing mainly within the number and arrangement of steps rather than in the fundamental content. For our project we adapt the six step scenario approach that Bishop et al. (2007) presented. This slightly adjusted approach has been successfully applied in previous research before (Nowack & Guenther, 2010; Nowack et al., 2011). It includes two phases, scenario development and scenario transfer, both divided into three sub-steps. While "Framing" and "Scanning" set the basics for the scenario project and identify relevant factors, the actual development of scenarios is done within the "Forecasting" phase. The "Visioning" phase integrates the developed scenarios into strategic decision making by "*envisioning the best outcomes*" (Bishop et al., 2007)[3]. "Planning" and "Acting" implement identified options into action, which has to be continuously controlled (Bishop et al., 2007).

3 O'Brien and Meadows provide a literature review on the development of visions (O'Brien & Meadows, 2001). For further insights see also Shoemaker (Schoemaker, 1992) or El Namaki (El-Namaki, 1992).

We implemented this approach as following:

Framing

In a kick off meeting the above mentioned purpose and objective of our project were discussed, fixing the time horizon for the scenarios on 2030. Thereby, the team of the main persons involved was built (2 CEOs, director of the head office, 2 researchers, and 1 research assistant). As the process was iterative, we combine steps that are closely connected.

Scanning and Forecasting

Desk research constituted the first part to answer our first main research question, (What future challenges shape decision-making at a public transport provider?) and especially on question 1a (How do environmental aspects and climate change (derived from large scales) affect the business?) and 1b (In total, what influences affect the business?). Therefore, the studies that were identified within our literature review on scenario studies were analyzed concerning ecological influences on transport and mobility as well as future challenges especially for the public transport (see the table in the Annex for the individual results). In addition, a literature review (analogous to the principle of the previous literature review) aimed to identify all relevant influences on the business environment of the public transport provider. Within this "Scanning", relevant stakeholders (based on the stakeholder model of Fassin, 2009; Freeman, 1984) and their potential influences on the corporate decision making (influenced by Porter (2008) are identified, followed by a focus on the macro-environment. For the latter, we used the common PESTE/L or STEEP analysis (Sheehan, 2009). All identified influence factors were assigned to political, economic, social, technological, and ecological influence spheres, where we integrated the legal sphere into the political. Thus, we ensured a comprehensive encapsulation of the state of the art of research. However, in order to adapt the results to the case-specific conditions, they were discussed with the public transportation provider.

To answer research question 1c (What are key challenges and how are they interrelated?) we use an innovative approach. First, we went into an in-depth discussion with the experts from the organization and identified key challenges which, according to their opinion, are highly relevant for the future development of their business. Second, we held a Fuzzy Cognitive Maps workshop in order to assess and evaluate all potential interrelationships in the system of key challenges. The method Fuzzy Cognitive Maps is based on the principle of cognitive mapping (Kosko, 1986). A closer look on the methodology FCM is given in Box 1.

The application of fuzzy cognitive maps in scenario planning has grown in recent years (Amer, Jetter, & Daim, 2011). Fuzzy cognitive mapping is a further development of Axelrod's (1976) notion of (causal) cognitive maps (CM) from 1976 (Kosko, 1986). He used CM in social science to analyze decision making within

social and political systems (Amer et al., 2011; Axelrod, 1976; Kandasamy & Smarandache, 2003; Kok, 2009; van Vliet, Kok, & Veldkamp, 2010). As a crucial step within scenario planning is to integrate the knowledge of different experts Jetter & Schweinfort (2011) highlight the "heterogeneity" of scenario planners), CM can represent the individual thoughts and subjective knowledge of experts using causal maps and thus "identify key issues of the scenario domain" (Amer et al., 2011; Goodier, Austin, Soetanto, & Dainty, 2010; Jetter & Schweinfort, 2011). To do so, a system of nodes and paths or arrows are arranged within a causal cognitive map, where the nodes represent "problem variables" (Hobbs, Ludsin, Knight, Ryan, Biberhofer, & Ciborowski, 2002), "concepts" (Amer et al., 2011) or "future issues, factors, events or outcomes" (Goodier et al., 2010), while the paths or arrows illustrate the causal relationships and dependencies between the concepts (Amer et al., 2011; Hobbs, Ludsin, Knight, Ryan, Biberhofer, & Ciborowski, 2002). In 1986, Kosko developed FCM as a tool based on the notion of CM with the goal of overcoming its shortcomings.

In short, "FCM is an extension and enhancement of a cognitive map with the additional capability to model complex chains of causal relationships through weighted causal links" (Amer et al., 2011; Kosko, 1997). While variables in CMs can only be true or false, in FCMs, the values of the variables are bounded by the interval [0,1] (Biloslavo & Dolinšek, 2010; Hobbs et al., 2002). Kosko states that "cognitive maps are too binding for knowledge-base building" (Kosko, 1986) and that FCM takes into account that the degrees of causality between the variables are mostly fuzzy or random. Another obstacle faced by CM is the indeterminacy of the map itself. If one concept or variable A is, for example, impacted by one concept B in a positive way and in a negative way by another C, one cannot decide whether concept A is decreasing, increasing, or staying unchanged (Amer et al., 2011; Jetter & Schweinfort, 2011).

To design an FCM, it is necessary to distinguish between its graphical and mathematical representations (van Vliet et al., 2010). First, all of the concepts that represent drivers in the system are represented as nodes and are arranged. Capturing the causal (indicating cause and effect) relationships (identified by the experts), directed edges are drawn by edges and thus connect the nodes (Kok, 2009; van Vliet et al., 2010; Amer et al., 2011). The connections are weighted based on the direction and strength of the relationship (van Vliet et al., 2010; Yaman & Polat, 2009). Given an increase in concept A and a decrease in concept B, the relationship running from concept A to B is negative, and the weight of the directed edge will be between [0,-1]. Conversely, an increase in concept A causing an increase in concept B represents a positive relationship with a weight between [0,+1] (Jetter & Schweinfort, 2011; Kok, 2009; van Vliet et al., 2010). These values are signed within the graphical representation with + or – (Jetter & Schweinfort, 2011), other verbal expressions or Likert-type scales (e. g. Cole & Persichitte, 2000; Jetter & Schweinfort, 2011; Kardaras & Karakostas, 1999).

Having described the graphical representation, the mathematical one remains to be considered. To capture concept dynamics, state vectors are defined for each concept that represent their values (Kok, 2009). The second component of calculating the FCM system is an adjacency matrix or square connection matrix (Jetter & Schweinfort, 2011), where all of the values of the relationships between all concepts in the system are summarized in one matrix (Kok, 2009). Matrix multiplication is conducted to simulate changes in the concepts within the FCM network. A new state vector can be calculated by multiplying the original state vector by the adjacency matrix, resulting in a new state. This matrix multiplication is iteratively applied (new state vector * adjacency matrix) until a steady state or a stop criterion is reached (Jetter & Schweinfort, 2011; Kok, 2009). By comparing the resulting state vector with the original state vector, one can detect whether a concept would increase or decrease (van Vliet et al., 2010). FCM is applied in a wide range of fields such as engineering or information technology, ecology, manufacturing, or product and strategic planning and even regarding health issues (Amer et al., 2011; Yaman & Polat, 2009). Recently, Jetter and Schweinfort (2011) developed scenarios for solar energy, while Amer et al.(2011) used FCM for scenario development in the wind energy sector. Applications of FCM to model situational awareness for soldiers (Jones, Connors, Mossey, Hyatt, Hansen, & Endsley, 2011), high pressure core spray systems (Espinosa-Paredes, Nuñez-Carrera, Vazquez-Rodriguez, & Espinosa-Martinez, 2009) or in the field of education (Cole & Persichitte, 2000) reinforce the heavy use and popularity of FCM.

Box 1: Fuzzy Cognitive Maps methodology

Together with two representatives (director and assistant) of the head office we (3 researchers, 1 research assistant) arranged the key challenges on a flip chart and draw arrows between them to represent the direction of impact. By assigning + (+++, ++, +) and – (---, --, -) to the arrows we evaluated the strength of impact. Within the workshop, the researchers restricted themselves mainly to the role of moderators, in order not to bias the evaluation by the experts from practice.

However, the selection and evaluation of key challenges is determined by the subjective know-how of the public transport provider representatives. In order to ensure high scientific validity and quality, we checked the results for "robustness". Therefore, we held a separate workshop without the public transport representatives, including two additional experts/researchers from the field of public transport research. We used the method of Cross Impact Analysis/Influence Analysis, a classic and commonly used method for the identification of key factors (see e. g. Gausemeier, Fink, & Schlake, 1998; Gordon & Hayward, 1968) to conduct an influence analysis within a cross impact matrix. The analysis of the gained results did not induce a need for adaptation of our origin selection, wherefore it is not further considered within this study. Given the robustness of our results, we continued our process.

Following Nowack (2011), we used the software FCMapper to create different simulations based on the designed Fuzzy Cognitive Map. In a workshop, representatives of all major departments in the organization discussed the simulations and created relevant input for the development of scenarios. In order to answer research question 1d (How can possible futures for the public transport provider look like?) and to create structured and plausible pictures of the future, we adapt the scenario-axes concept (van't Klooster & van Asselt, 2006) (as applied for example at the SRES scenarios of the IPCC or the Millenium Ecosystem Assessment scenarios). As van t'Klooster and van Asselt (2006) state: "This approach is aimed towards identifying the two most important driving forces, i. e. those developments that are both very uncertain (and therefore can develop into different directions) and could have a decisive impact for the region, the subject, the organization, etc." (van't Klooster & van Asselt, 2006, p. 17). In discussion with the organization we identified the two main axes and developed 4 different storylines of small-scale scenarios that are underlined with the findings of the previous process.

In order to answer our 2nd research question (How can large-scale scenarios (possible futures) be transferred to small-scale sustainable decision-making?) the process was as followed.

Visioning, Planning, and Acting

Within the Visioning phase, we went into an in-depth discussion with the public transport provider to draw conclusions or consequences and thus answer 2a (What consequences are derived from small-scale scenarios for small-scale sustainable decision-making?). Using the principle of a SWOT-analysis, we discussed strengths and weaknesses as well as the opportunities or threats that the possible futures might imply (Hill & Westbrook, 1997). Based on that discussion the need for an adaptation of the existing corporate strategy orientation was considered, answering on 2b (Which strategies can be developed for small-scale sustainable decision-making?).

To answer research question 2c (How can small-scale strategies be transferred into small-scale sustainable decision-making?) we follow the main part of the scenario transfer process that certainly is to identify and discuss possible options for adaptation and action. Thereby, in an iterative and still ongoing process, relevant fields for action were and will be identified and potential actions implemented. The implementation of these actions will be integrated in the future strategy plan.

Controlling

Possible barriers that could hinder the fulfillment of the implementation plan and suitable solutions have to be identified (Moser & Ekstrom, 2010). Using the literature review on influence factors, possible barriers have already been discussed. However, we decided to review the results of the implementation within 1 or 2 years.

Our results of the now described procedure will be presented in the following results section. Thereby, our research questions will be subsequently answered.

Results

Framing

By defining the focus of the case study, the participants fixed the year 2030 as time horizon for the development and transfer of small-scale (case-specific) scenarios.

Our research question 1a (How do environmental aspects and climate change (derived from large scales) affect the business?) and 1b (In total, what influences affect the business?) are answered by the findings of the initial (see the categories in the table in the Annex) and additional literature review, that were discussed and commented concerning the case-specific conditions.

Scanning and Forecasting

As a result, 51 factors (12 social, 6 technological, 14 economic, 15 ecological, and 4 political/legal factors) were identified and arranged according to the PESTE or STEEP method, represented in Figure 2.

The list of ecological influences mainly depends on the results of an analysis of impacts of climate change on the case area (done by meteorologists in a research project on climate change adaptation). Thereby, we distinguish average climate changes

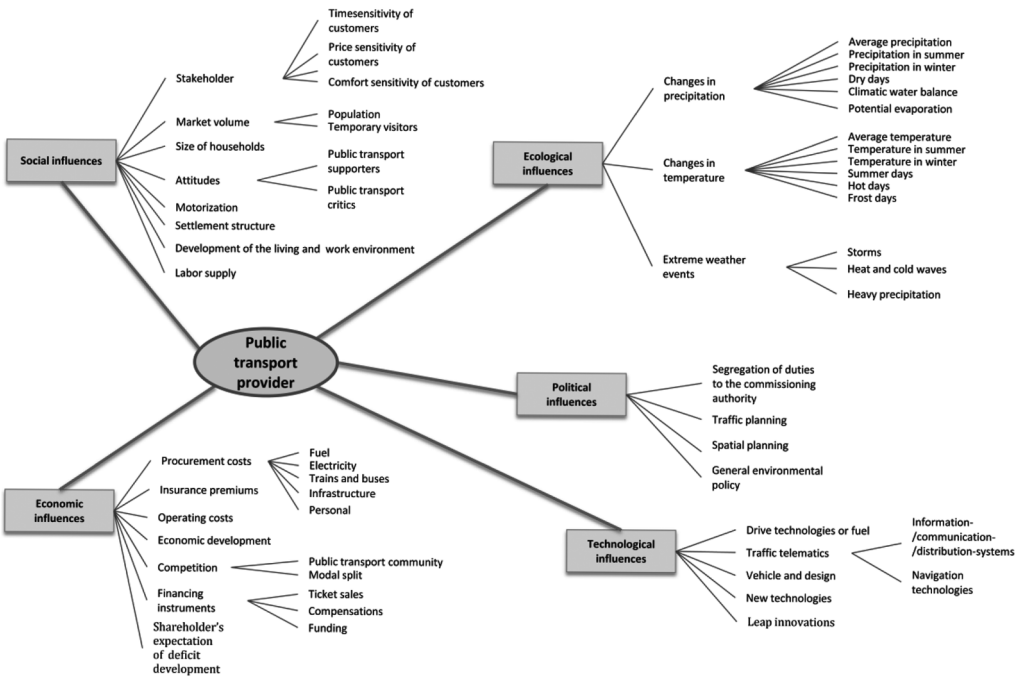

Figure 2: PESTE(L)/STEEP analysis of influence factors

and extreme weather events. Not surprisingly, our findings are consistent with research (e. g. Koetse & Rietveld, 2009). Climate change and especially the impacts of extreme weather events have a major affect on the public transport sector (Koetse & Rietveld, 2009), given the complex relationship between infrastructure, technology, time schedules, and volatile customer behavior.

In the past, the public transport provider experienced impacts of flooding causing infrastructure damages, long phases of disturbances and reconstructions of their business operation. Long-term heat waves negatively influenced the comfort of both drivers and customers in buses and trams (not airconditioned). The opposite, cold waves or heavy snowfall, contain a high risk and uncertainty about possible accidents and disruptions of time schedule. Storms can cause major damages to the infrastructure (e. g. electricity supply interrupted by fallen trees). In general, the impacts of extreme weather events on road safety are serious (Koetse & Rietveld, 2009). However, indirect costs due to network effects (e. g. costs for delays) as identified by Koetse and Rietveld (2009) or other researchers (e. g. Suarez, Anderson, Mahal, & Lakshmanan, 2005) complement the direct costs of damages. The fact that the occurrence and strength of extreme weather events cannot be predicted means that those costs will remain incalculable and increases the uncertainty for the case company.

However, prognoses for average changes (in precipitation and temperature) exist for the case region. But, according to the case organization average changes do not strongly affect their business. Rather, predicted warmer and wetter winters with less snow might have positive effects (less snow clearing needed) on the daily operation. Increasing tourism in summer might increase the demand for public transport services (e. g. Koetse & Rietveld, 2009; Hamilton et al., 2005).

Besides direct ones, indirect impacts of environmental aspects and climate change are part of the other PESTE(L) areas. In the social category, the influence factor "Attitudes" covers also the mobility behavior of individuals, which might be affected by direct impacts of climate change (e. g. flood or heavy rainfall) or part-affected by a strongly or poorly marked environmental awareness. If, due to caused by the impacts of climate change tourism increases, then subsequently the market volume of temporary visitors increases. Not to forget, the indirect impact of climate change on the availability of resources and energy might increase its prices and thus increase the procurement costs (see Stern (2006) for a closer look on the impacts of climate change on economics). The technological influences "drive technologies or fuel", "vehicle and design", and "new technologies" are equally connected to environmental aspects. Given increasing effort on environmental protection and mitigation of greenhouse gas emissions, the development of environmentally friendly (drive) technologies and substitution of fossil fuels by renewable energies (e. g. hybrid) will play a major role in the future (e. g. Chapman, 2007). Chapman (2007) states, "Pressure is growing on policy makers to tackle the issue of climate change with a view to providing sustainable transport" (Chapman, 2007, p. 354). Thus, the case organization expects an increasing

relevance of political influences concerning climate policy that appears directly (general environmental policy) or indirectly via traffic or spatial planning. Not only regulations and guidelines (e. g. on (bio)fuels or energy-efficiency) (e. g. Creutzig, McGlynn, Minx, & Edenhofer, 2011) or economic climate policy instruments (e. g. fuel taxes) (Sterner, 2007) might increase pressure on the public transportation sector. Rather, the public promotion of public transportation (buses) as an alternative and better integration into other transport networks might be part of a "bigger sustainable development policy" (Chapman, 2007, p. 363).

Thus, given these remarks and with a closer look on Figure 1, we can draw an interim summary concerning our research questions 1a and 1b.

Environmental aspects and climate change highly affect the business of the public transportation provider, mainly through direct impacts of extreme weather events. However, climate change affects indirectly through a variety of other social, economic, technological, or political influences. But, we have to state: Climate change is not the only challenge. Rather, major challenges such as demographic change (and thus changing attitudes and demand), technological change (e. g. development of new technologies), or even increasing globalization (effect on energy and fuel availability and prices) have major influences. Finally, the different factors are highly interrelated in a complex system.

Answering 1c and to identify the key challenges and to evaluate this complex system we continued our process by applying the Fuzzy Cognitive Maps method.

The in-depth discussion identified in total 19 main challenges (see Table 1). In addition to short descriptions of the challenges, BT represents the respective basic trends that are assumed for likely future development of the key challenges and is important in providing the initial point for the simulations in the Fuzzy Cognitive Maps.

Key factor	**Social key challenges**	**BT**
Development of market volume	• While, according to statistical forecasts, the total population for Germany will decrease by 2030, for the catchment area of the public transport provider it will increase. • Due to demographic change, the structure of customer groups will change too. • Increasing popularity of city and weekend tourism will influence the market volume. • As a basic trend, an increase of possible market volume is assumed, challenging the public transport system with higher demands.	↑
Public transport support	• Attitudes towards the use of public transport either can be supportive or refusing, depending on various variables such as environmental-, cost-, safety awareness, as well as on the public image. • An increasing public transport support will also promote creativity and innovations.	↑

Key factor	**Social key challenges**	**BT**
Increasing time sensitivity	• Public transport users demand to reach their goal within a short time and disapprove of long waiting times. • This challenges a flexible and efficient operational planning.	↑
High price sensitivity	• As already very high, price sensitivity is strongly dependent on economic developments and differs within customer groups. • An assumed high price sensitivity will influence future price determinations and strengthen the cost pressure.	→
Increasing comfort sensitivity	• A high comfort of public transport services includes inter alia low transfer frequency, barrier-free accessibility, and the possibility of transferring bikes or baby carriages. • The fulfillment of all requirements for high comfort challenges the operational planning.	↑
Key factor	**Technological key challenges**	**BT**
Innovations in new drive technologies	• The development of innovations in drive technologies could improve the performance as well as comfort standards of vehicles and develop a more efficient passenger transport.	↑
Development of information/communication/distribution systems	• An improvement of these systems will facilitate traffic control and increase safety of public traffic. • Intelligent distribution systems will optimize internal costs.	↑
Increased requirements on the navigation technologies	• To ensure the performance of navigation systems under changing and heavy conditions, innovations and the state of the art of navigation technologies need to be applied.	↑
Development of new technologies	• In general, the development of new technologies defines a challenge to the public transport provider, due to the occurrence of competitive means of transport, influencing the modal split.	↑
Key factor	**Economic key challenges**	**BT**
Increase of procurement costs	• Following previous developments, prices for fossil fuels as well as electricity will increase. • The dealing with higher procurement costs will mark a great challenge for the organization.	↑
Strong competition within the public transport community	• Although the current situation does not provide many conflicts with competitors, an increase in competition would have far-reaching effects on the operational and financial corporate design.	↑
Strong competition within the modal split	• The development of new means of travel as well as changes of the shares within the modal split would provide stronger competition for the organization.	↑
Shareholder expectations of deficit development	• Shareholder expectations are dependent on a variety of factors such as the development of the area of responsibility. • According to the head office, a strengthened cost pressure will lead to a tightening of shareholder expectations.	↑

Key factor	**Social key challenges**	**BT**
Ticket sales and revenues	• The development of ticket revenues is strongly connected to ticket prices and sales, but also on compensations and funding. Little changes can cause far-reaching consequences for corporate financial planning. • As they are the main source of income, the development of ticket revenues is a major challenge. • As a basic trend, an increase in ticket sales and revenues is assumed.	↑
Decrease of compensation	• Compensations are a very important condition to be able to provide a broad offer of payable public transport services. For example, federal compensations allow for the offer of cheaper ticket prices for students. • A decrease would strengthen the cost pressure enormously.	↓
Decrease of funding	• Funding is necessary to ensure investments in the development of new technologies. • Analog to compensations, a decrease would strengthen the cost pressure.	↓
Key factor	**Ecological key challenges**	**BT**
Occurrence of extreme weather events	• Heavy precipitation, resulting in flood events, or fallen trees, caused by major storms, could block streets and areas for buses and trams. • Besides the operational planning, vehicle fleet and infrastructure is strongly impacted too.	↑
Key factor	**Political key challenges**	**BT**
Segregation of duties to the commissioning authority	• Due to the fact that the city government holds 100 per cent of the shares, the future regulating impact on the public transport provider is enormous. • According to the head office, a transfer of competences from the organization to the commissioning authority is possible and would shape the corporate autonomy.	↑
Public transport-friendly traffic and spatial planning	• Although influenced by the political regulations at European, nationwide, and federal levels, city governmental decisions on traffic and spatial planning have the greatest impact on traffic routing and infrastructure development. • As a future trend, a public transport-friendly regulation is assumed.	↑

Table 1: Key challenges

Following our methodological approach, the identified key challenges were arranged to a Fuzzy Cognitive Map and evaluated according mutual interrelationships. Figure 3 presents the complex and fuzzy system for the public transport provider.

At first glance, the clarity and significance of the map might be doubted. Thus, the illustration explains the fuzziness of the map well. Using a finer-grained analysis, one will recognize that *ticket sales (and revenues)* clearly resembles the main item on the

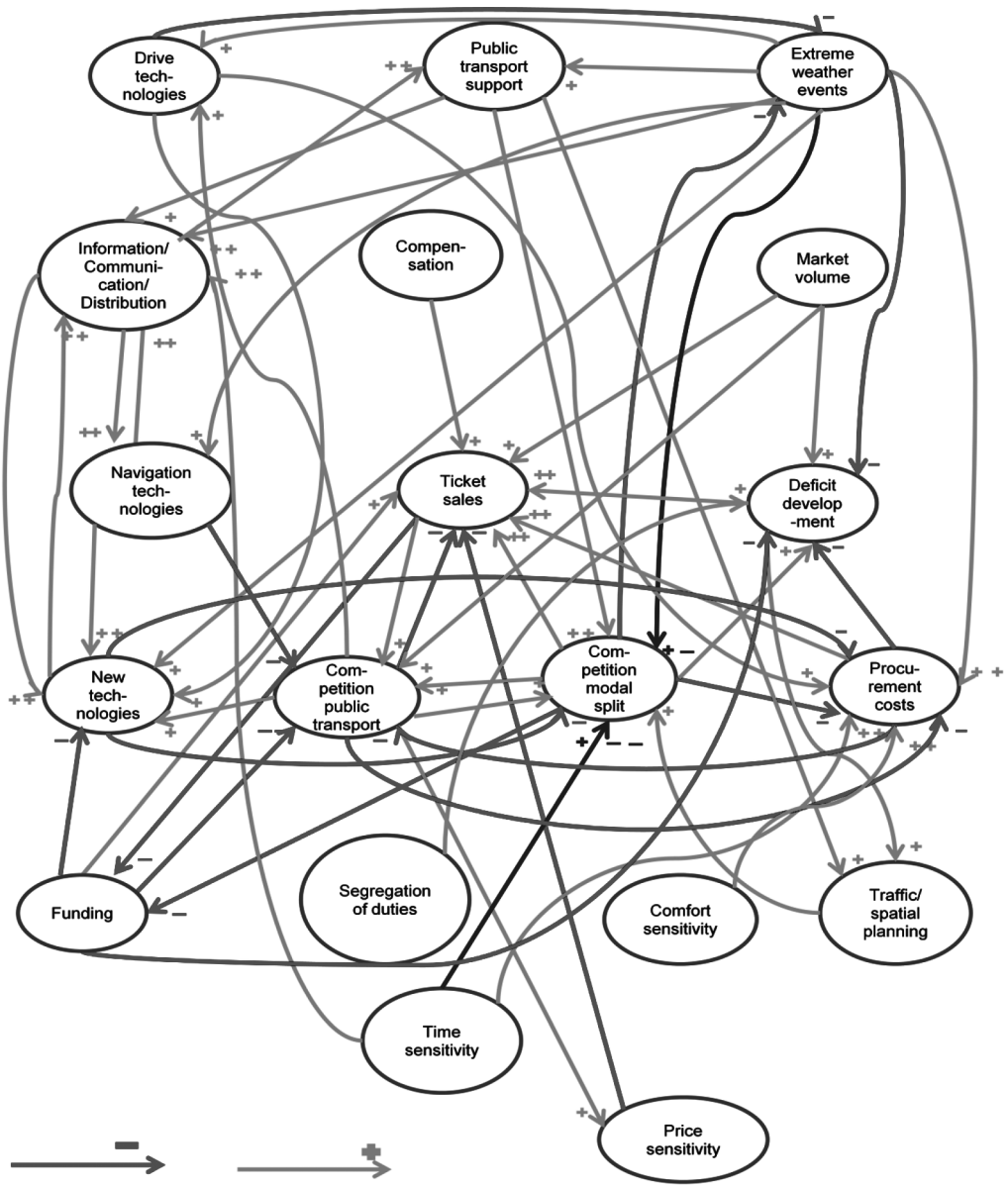

Figure 3: Designed Fuzzy Cognitive Maps

map, being influenced by eight other factors (while it only has two outgoing arrows), which provides a good characterization of its high degree of dependence within the system. It is clear that small changes may have substantial impacts on ticket sales and therefore on the financial situation of the organization (e.g., if procurement costs decrease, ticket prices might decrease and ticket sales might therefore increase). Therefore it could be assumed that ticket sales also have a high degree of influence within the system. However, all of the key factors were checked separately for possible relationships, as was the resulting map, and only influences on funding (*decrease of funding;* if ticket sales increase, funding will be reduced) and competition with other public transportation competitors (strong *competition within the public transport community;* increasing ticket sales has a positive influence on market position) have significant amounts of influence. We detect a high degree of passivity (meaning that are more influenced than to influence others) for the technological factors *development of information/communication/distribution systems, increased requirements on the navigation technologies and development of new technologies* as well as the financial factors *increase of procurement costs, strong competition within the modal split and strong competition within the public transport community.* Furthermore, *decrease of compensation, increasing comfort sensitivity and segregation of duties to the commissioning authority* are nearly isolated in the system, as a result of the experts' assessment that they are highly connected to other key factors and therefore have no direct influence on the system themselves.

Small-scale scenarios

Answering our research question 1d (How can possible futures for the public transport provider look like?), we present the developed small-scale scenarios to 2030 for the public transport provider. With "Policy support" and "society/consumer behavior", two main axes were identified that could structure possible futures for the public transport provider. Thereby, "Policy support" concludes the general appreciation of public transport by policy (based inter alia on the key challenges *public-transport friendly traffic and spatial planning* and *segregation of duties to the commissioning authority)*. Thus, one could distinguish futures where public transport has priority for policy decision makers or not, which logically influences the availability of funds (see the key challenges *decrease of funding and compensation and ticket sales and revenues*. "Society/Consumer behavior" (including *development of market volume, public transport support, increasing time sensitivity, high price sensitivity, increasing comfort sensitivity)* distinguishes between a mono-modal (customers limited to one means of transport) and a multi-modal (use of multiple means of transport, see also *strong competition within the modal split*). Thus, 4 different small-scale scenarios can structure possible futures for the public transport provider, presented in Figure 4.

- Car society: This scenario assumes American conditions, where cars are a symbol of status and main mean of transportation. Limited funds complicate adaptation and flexibility in order to compete effectively on a mono-modal society.

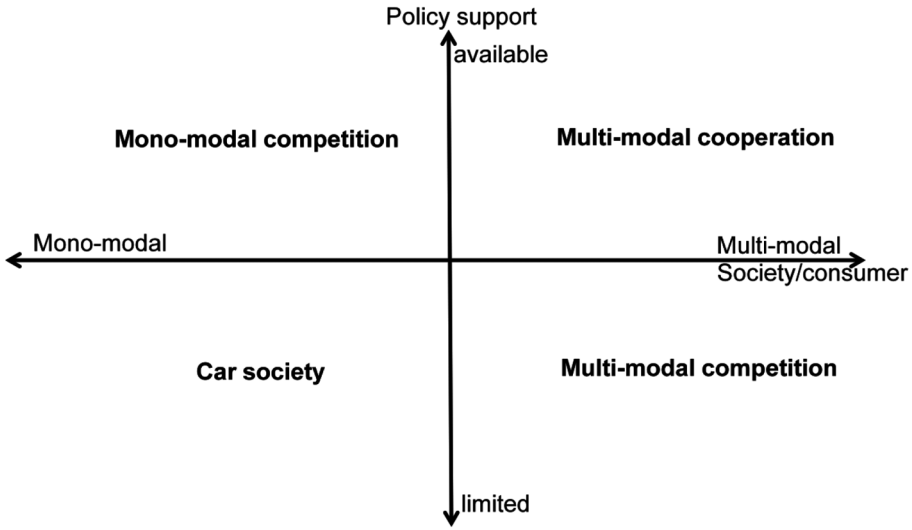

Figure 4: Possible futures for a public transport provider

- Mono-modal competition: In this possible future a strong competition for the favor of the mono-modal society is ongoing. Available funds and a stronger priority of public transport in policy enable an effective competition between different means of transport. Alternative and sustainable public transport concepts might gain and bind new customers that are not necessarily committed to one mean of transport (e. g. car).
- Multi-modal competition: Given non political priority and limited funds, public transportation faces uncomfortable conditions within the competition for multi-modal customers. New public transport concepts (e. g. bike or car sharing) enrich the mobility market and increase competition.
- Multi-modal cooperation: This scenario consciously contains a strong normative character (see Börjeson et al., 2006) as it represents a desirable future for the public transport provider with a "good together" with other means of transport.

In the following, we restrict on the use and transfer of the desirable future "multi-modal cooperation" (while strategy options for other scenarios were discussed too). Following the normative approach, strategies and actions should be developed in order to deal with or even reach that desirable future. First, the storyline of the "multi-modal cooperation" scenario should be described.

The main driving force in this future is policy decision-making that implements the "bigger sustainable development policy" (Chapman, 2007, p. 363), has a somehow top-down effect on all areas. An environmental friendly (environmental) policy, a sustainable regional and spatial planning and a stronger political support frame a general policy priority for public transport. Not only the development but also the imple-

mentation of new (environmentally friendly and energy efficient) technologies will be supported. Thus, a transition to hybrid and other new drive technologies is possible. Within these comfortable surroundings, a great variety of offers for sustainable transport (e. g. car or bike sharing) has evolved. However, these should not be seen as competitors. Rather, all means of transport benefit from a highly multi-modal society that chooses concerning comfort-sensitive reasons, different and alternative means of transport.

Visioning, Planning, and Acting

Focusing on the example of the "multi-modal cooperation" scenario, we will describe how we discussed conclusions from the possible small-scale scenarios for the future strategic orientation of the organization and thus answered research question 2a (What consequences are derived from small-scale scenarios for decision-making?).

First, strengths and weaknesses of the organization were reflected. The public transport provider has a strong and comprehensive system of infrastructure (road and rail lines) and drive fleet and information and distribution technologies that allows flexible reaction to potential disturbances. Furthermore, there is a good stock of well qualified and experienced employees. At the same time, the long-term lifetime and investment horizon of the infrastructure provide a certain ligation and thus decrease flexibility.

The chances for the public transport provider within a possible "multi-modal cooperation" future mainly can be seen in the public transport friendly environment conditions. Having the funds, the public transport provider is able to invest in new technologies, maintenance and renewal of infrastructure or the extension of information and distribution technologies. Thus, it can present itself to the multi-modal society as a provider of sustainable transport services. However, one risk in this possible future could be an increased competition with alternative means of transport concepts (e. g. bike or car sharing).

In the following, the final research questions 2b (Which strategies can be developed for small-scale sustainable decision-making?) and 2c (How can small-scale strategies be transferred into small-scale sustainable decision-making?) will be answered. Based on this SWOT analysis, potential strategies in this possible future can be (the strategies already include potential actions for implementation):

- Service provider: Extend the service offer for customers and thus become a full mobility service provider
  - Communicate: Use and extend new ways of information and distribution (e. g. extend existing mobile time schedule)
  - Cooperate: Extend existing cooperation with alternative mobility concepts (e. g. car sharing, bike sharing, park and ride)
  - Event manager: Extend the support and service for tourists and temporary visitors (e. g. cooperation with local event managers)

- New technologies: Analyze and implement (appropriate) new technology developments in order to actualize (e. g. information and distribution technologies) or increase efficiency (e. g. drive technologies) of existing technologies

Potential strategies dealing with the impacts of climate change can be:
- Adaptation: Adapt to the impacts of climate change based on the experiences of previously experienced extreme weather events (e. g. build new and adapt old infrastructure to be resistant against future flood or storm events)
- Flexibility: Create more flexibility to react on the occurrence of extreme weather events (e. g. by using special traffic time schedules in cases of extreme weather events)

Summary and Discussion

Summarizing, we want to present the essential cognitions of our findings. By answering our first research question we identified future challenges that shape small-scale decision-making of a public transport provider. We proved that climate change is a highly relevant future challenge for the organization, given its direct (e. g. flood) and indirect (e. g. regulations, environmental policy) impacts on the corporate business. However, our study showed the following: Climate change is just one challenge of a great number (51 influences in total). Rather, for organizations it is crucial to not consider them independently. Mutual cause-effect relationships exist between separate challenges, forming a complex system. We found that the Fuzzy Cognitive Maps method was appropriate to assess the complexity of a system of 19 key challenges at a case public transport provider. The thereby gained cognitions (basis trends and implications) frame the basis for a set of 4 small-scale scenarios. To structure them, two main driving forces society/consumer behavior and funds/policy priority were identified. The scenarios present possible future that are less ("car society") or more desirable ("multi-modal cooperation"). Following a normative character (how can a goal be reached), the "multi-modal cooperation" represents a very catchy example of the developed scenarios and thus was used to answer our second research question and transfer the scenario to a small-scale and thus derive appropriate strategies and actions for sustainable decision-making. Given such a desirable future, the public transport provider should use the favorable conditions to extend existing and induce new cooperation with alternative transport and mobility concepts (e. g. car and bike sharing). By evolving as a service provider for mobility, the case organization would be able to gain long-term shares within a sustainable mobility market.

Our findings show that there is a great variety of possibilities for the public transport provider to integrate long-term thinking in their decision making. Scenario planning assists this process. And although the actual occurrence of e. g. the "multi-modal cooperation" scenario is not guaranteed, dealing with these small-scale scenarios encourages the decision-makers to think outside their small-scale box. Existing

strategy plans are reconsidered and potentially adapted in order to "prepare" for future developments and thus to ensure sustainable decision-making.

In the following, we want to critically reflect on our study. First, concerning our methodological approach, we can state that scenario planning and especially Fuzzy Cognitive Maps is highly appropriate for the practical application at an organization. The method allowed us flexibility, stimulated thinking, and encouraged participation. Thus, our objective was achieved and a professional but also familiar atmosphere bolstered cooperation. One might argue that similar studies in that field of research integrate more experts (e. g. 30 experts within a Delphi approach at von der Gracht & Darkow, 2010). However, they usually (as the case for von der Gracht & Darkow (2010)) develop scenarios for whole industries. Thus, given our small scale, the restriction on the participating experts is appropriate, as they cover both industry expertise and small-scale organization specific know-how. By checking our results for robustness, we ensured high scientific validity and quality of our results.

Furthermore, our findings are case-specific, but decision-making on the organization level is specific too. Nevertheless, many of our findings can be easily transferred to other public transport providers. Moreover, the methodology (to transfer large-scale scenarios to small-scale decisions) can be transferred to other companies and thus is generalizable. Thus, we conclude that our case study fulfills the two conditions of an exemplary case study with significant results as stated by Yin (2009): (1) Our individual case is of general public interest as "human survival and societal interaction depend on the ability to move people and goods" (IPCC, 2007, p. 328). (2) We address issues that are not only nationally but also internationally important, both in policy and practical terms (Yin, 2009).

Of course, the policy and practical success of the project depends on the use and further development of the strategic thoughts conceived in this study, which should be controlled periodically (Yin, 2009). But for now, the innovative approach and the assessment of the complexity were already highly appreciated by the participants. Rather, such exercises are required to make large-scale scenarios useable and transferable to the small-scale decision-making level, i.e. the organizational level. Thus, we encourage both research and practice to scrutinize our findings, as more case studies are needed that present best practice examples for decision-makers at the small scale.

Annex

Overview of the identified studies

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Akerman, J.	2005	Sustainable air traffic	Global/large	2050		
Akerman, J.; Höjer, M.	2006	Sustainable transport system	Sweden/large	2050		
Andersen, O. et al.	2004	Public transport/Environmental Reporting	Oslo (Norway)/ small	2016		
Armstrong, J.; Preston, J.	2011	Alternative railway futures	Global/large	2055		
Auvinen, H.; Tuominen, A.; Ahlqvist, T.	2012	Transport system	Finland/large	2100		
Azar, C.; Lindgren, K.; Andersson, B.	2003	Fuel choices in transportation sector	Global/large	2100		
Banister, D.	2000	Sustainable mobility	European Union/large	2020		
Banister, D.; Hickman, R.	2013	Sustainable transport	Global, Delhi (India)/large	2030		
Bracher, T.; Diekelmann, P. (Ed.)	2004	Public transport	Berlin (Germany) medium	2015		
Brigham, L.	2008	Shipping (transport)	Arctic/large	2020 and 2050	Climate change increases marine access	
Bright, R.; Stromman, A. H.	2010	Future role of biofuels	Northern Europe, Fenno-Scandinavian Region/large	2050		

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Bundesministerium für Verkehr,Bau und Stadtentwicklung (Ed.)	2006	Future development of mobility and regional structures	Germany/ large	2050		
Ceron, J.; Dubois, G.	2007	Sustainable tourism and mobility	France/large	2050		
Charles, M. B.; Ryan, N.; Kivits, R. A.	2012	Sustainable intercity transport	Australia/ large	Not specified		
Chatterjee, K.; Gordon, A.	2006	Transport	United Kingdom/large	2030		
Christidis, P.; Hidalgo, I.; Soria, A.	2003	Drive and fuel technologies	Global/large	2020	Environmental limits	
Davies, F.; Moutinho, L.; Hutcheson, G.	2005	Strategic planning in the European Air industry	Europe/large	Not specified		
DB Mobility Logistics AG; McKinsey & Company (Ed.)	2010	Transport/ Mobility/ Railway	Germany/ large	2025	Framework conditions for climate mitigation	Economic and social development, policy
Eastman, R.; Miles, J.; Wilkinson, J.	2004	Future highway transport	United Kingdom/large	2030	Air quality, resource utilization	
Eelman, S.; Schmitt, D.	2004	Future requirements for airplane (transport) cabins	Not specified	2030		
Flotzinger, C.; Hofmann-Prokopczyk, H.; Starkl, F.	2008	Sustainable development of Economy and Logistics	Austria/large	2030	Policy, society	
Geurs, K.; van Wee, B.	2000	Sustainable transport	Netherlands /large	2030		

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Gonzalez-Feliu, J. et al.	2013	Logistics and freight transport systems	Lyon (France) /medium			
Gül, T. et al.	2009	Alternative fuels for personal transport	Global/large	2100		
Harvey, L. D. D.	2013	Transportation (Zero emissions)	Global/large	2100		
Hickman, R.; Banister, D.	2007	Sustainable transport	United Kingdom/large	2030		
Hickman, R. et al.	2012	Sustainable transport	Oxfordshire (United Kingdom) /medium	2030		
Hinkeldein, D.	2009	Future requirements for traffic management	Germany/ large	2020		
Hunsicker, F. et al.	2008	Megatrends in the transport market	Germany/ large	2015 and 2030		
ICCR (A) (Ed.)	2004	Transport and Mobility	European Union/large	2020		
Institut für Mobilitätsforschung (Ed.)	2010	Future of Mobility	Germany/ large	2030	Extreme weather events, relevance of environmental aspects in policy	Decrease of demand due to rural migration, no infrastructure investments
Janssen, A. et al.	2006	Natural gas vehicles	Switzerland /large	2030		
Juul, N.; Meibom, P.	2013	Road transport	Northern Europe/large	2030		
Kampker, A.; Lehbrink, H.; Schmitt, F.	2009	E-Mobility	Germany/ large	2020		

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Kloess, M.; Rechberger, J.; Ajanovic, A.	2008	Market potentials for E-Mobility	Austria/large	2050		
Kollosche, I.; Schulz-Montag, B.; Steinmüller, K.	2010	E-Mobility	Berlin (Germany) /medium	2025	Regulations	
Kwon, T.-H.	2005	CO2 emission trends of car travel	United Kingdom/large	2030		
Lopez-Ruiz, H.; Crozet, Y.	2010	Sustainable transport	France/large	2050		
Malone, K. et al.	2001	Strategic model for long-term travel demand forecasting	Netherlands /large	2030		
Matsuoka, I.; Allen, H.	2011	Sustainable transport	Global/large	2050		
Mazzarino, M.	2012	Strategic scenarios for Logistics	Global, Europe/large	2020		
McCollum, D.; Yang, C.	2009	Sustainable transport	United States/ large	2050		
Nava, M. R.; Daim, T. U.	2007	Alternative fuels	United States/ large	40 years	Environmental concern, oil price	
Nijkamp, P. et al.	2000	Transport infrastructure investments	Not specified	Not specified		
O'Brien, F.; Meadows, M.	2013	Strategy development in the transport sector	United Kingdom/large	Not specified		
OECD (Ed.)	2000	Environmentally sustainable transport	Global/large	2030		
Page, S.; Yeoman, I.; Greenwood, C.	2009	Sustainable tourism transport	Scotland/ small	2025	Environmental policy	

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Peeters, P.; Dubois, G.	2010	Sustainable tourism travel	Global/national/large	2030 and 2050		
Piecyk, M.; McKinnon, A.	2010	Trends in logistics and supply chain management	United Kingdom/large	2020	Emission trading scheme	
Queensland Department of Transport; Queensland Department of Main Roads (Ed.)	2000	Transport portfolio	Queensland (Australia) /medium	2025	Global climate change, urban air quality, water availability	Bad image, personal safety, underfunding
Reynaud, C.	2000	European reference scenarios	Europe/large	2020		
Robèrt, M.; Jonsson, R.D.	2006	Sustainable transport	Stockholm (Sweden) /medium	2030		
Salling, K.; Leleur, S.; Jensen, A.	2007	Transport infrastructure	Oresund (Denmark) /medium	Not specified	Policy	
Scenario Management International AG (ScMI) (Ed.)	2010	Mobility in agglomeration areas	Germany/ large	2030	Environment and Environmental Policy	Decreasing funding, loss of attractiveness, competition
Schade, W. et al.	2011	Sustainable transport	Germany/ large	2050	Climate change, extreme weather events, tourism, policy	
Schippl, J. et al.	2008	Long distance transport	Europe/large	2047		
Scholz, R. et al. (Ed.)	2004	Mobility	Basel (Switzerland)/ medium	2025		
Schroeder, M.; Lambert, J.	2011	Infrastructure policy and planning	Not specified	Not specified		

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Shayegan, S.; Pearson, P.J.G.; Hart, D.	2009	Refuelling infrastructure costs	London (United Kingdom) /medium	2025		
Shell Germany Oil GmbH (Ed.)	2009	Sustainable car mobility	Germany/ large	2030	Policy	Decreasing public transport services in rural areas, increase of infrastructure costs
Schuckmann, S.W. et al.	2012	Transport infrastructure	Global/large	2030		
Shiftan, Y.; Kaplan, S.; Hakkert, S.	2004	Transportation system	Tel Aviv (Israel) /medium	2030		Low service level of public transport system
Spielmann, M. et al.	2005	Transport systems	Switzerland /large	2020	Environmental awareness	
Stead, D.; Banister, D.	2003	Transport policy	Europe/large	2020		
Tegart, G.; Jolley, A.	2001	Sustainable transport	Asia-pacific/ large	2020	Global warming, coastal flooding, migration	
Topp, H.	2007	Urban and regional planning of mobility and transport	Germany/ large	2030		Underfunding, decreasing demand, longer cycle times, outdated vehicle fleet, safety risk, bad image,
Turton, H.	2006	Sustainable automobile transport	Global/large	2100		

Author	Year of publication	Focus of study	Region/scale	Time horizon of scenarios	Ecologic influences on transport	Challenges for public transport
Ubbels, B.; Rodenburg, C.; Nijkamp, P.	2003	Sustainable transport	Global, Europe, Netherlands /large	2020		Decreasing public transport service in rural areas
Ülengin, F. et al.	2010	Sustainable transport	Not specified	Not specified	Emission limits for vehicles	
Varho, V.; Tarpio, P.	2012	Transport sector	Finland/large	2050		
Vergragt, P.; Brown, H.	2007	Sustainable mobility	Boston (United States) /medium	2050		
Vespermann, J.; Wald, A.	2010	Intermodal integration of airports	Europe, America, Asia/ large	2038	Climate change mitigation, compensations	
von der Gracht, H.; Darkow, I.	2010	Logistics service industry	Germany/ large	2025	Climate protection regulations, awareness	
Wallentowitz, H. et al.	2003	Future car technologies	Germany/ large	Not specified		
Webel, S.	2010	Traffic-/transport system	New York (United States)/medium	2030	Environmental policy	
Winebrake, J.; Creswick, B.	2003	Future hydrogen fuel technologies	Not specified	15–20 years		
World Business Council for Sustainable Development (WBCSD) (Ed.)	2004	Sustainable mobility	Global/large	2030	Flooding	Rural migration, decreasing demand

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Zusammenfassung

Der Transportsektor übernimmt eine der wichtigsten Aufgaben in der Gesellschaft: den Transport von Menschen und Gütern. Um einen nachhaltig entwickelten Transport zu garantieren, müssen Entscheidungsträger, sowohl auf politischer als auch auf Unternehmensebene zukünftige Herausforderungen erkennen, mögliche Zukünfte entwickeln und nachhaltige Entscheidungen für die Gegenwart ableiten. Die Forschung fokusiert auf Szenarienentwicklung in großen Skalen und vernachlässigt dabei den Transfer auf kleine Skalen. Um diese Forschungslücke zu füllen, wenden wir die Szenariomethode im Rahmen einer Fallstudie bei einem ÖPNV-Anbieter an. Dabei werden zwei Forschungsfragen beantwortet: (1) Welche zukünftigen Herausforderungen beeinflussen die Entscheidungsfindung beim ÖPNV-Anbieter? und (2) Wie können großskalige Szenarien auf kleinskalige nachhaltige Entscheidungen übertragen werden. Dabei wurden für ein wünschenswertes Szenario (eines von 4) mögliche Strategien auf dem Weg zu einem vollkommenen Service-Dienstleister entwickelt.