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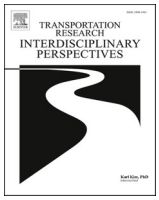

Transport services and mobility behavior in the Ruhr Region. An analysis of the potential for system transformation and behavior change from the provider's perspective

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ABSTRACT

Mobility is a key factor in shaping sustainable urban development, yet many regions face challenges in transforming their transportation systems to meet modern demands. Despite advancements in technology and growing awareness of environmental concerns, car usage remains disproportionately high in several metropolitan areas. Understanding the structural characteristics and governance factors influencing mobility systems is crucial for identifying effective pathways for transformation.

The Ruhr region exemplifies these challenges with its unique metropolitan structure and reliance on cars despite its dense population and extensive public transport network. While research on mobility behavior exists, much of it centers around user perspectives, often neglecting provider-side dynamics and governance levels.

This article addresses this gap by examining the transformation of the Ruhr region's transportation system from the perspective of mobility providers and public authorities. Through expert interviews with representatives from these institutions, the study explores potential changes and transformation paths while linking provider-related factors to established behavioral theories. The analysis differentiates between governance levels for the article to offer actionable recommendations for stakeholders.

From the providers' perspective, public transportation requires greater flexibility, improved acceptance, and a revision of funding and coordination structures away from mere profit orientation. Surveying and incorporating travelers' individual needs and contexts into service design could foster acceptance among users. Additionally, integrating sharing and on-demand solutions within a synchronized public transport framework could improve flexibility. These services should not be treated as isolated components but as integral elements of a holistic transformation focused on evolving usage practices within the mobility system.

Introduction

The transformation of transportation systems is a global challenge, driven by the urgent need to address climate change, adapt to shifting demographic patterns, and respond to (external) shocks such as pandemics or natural disasters. On a general level, transportation systems worldwide are under increasing pressure to evolve in response to environmental imperatives and societal changes. Climate change demands significant reductions in greenhouse gas emissions from all sectors, including transportation. At the same time, urbanization trends and demographic shifts create uneven patterns of population growth: large cities continue to expand while rural areas face population decline. These developments raise fundamental questions about the future of mobility systems and their ability to meet diverse needs sustainably.

The Covid-19 pandemic further underscored the vulnerability of existing transport systems: In addition to the well-known immediate reduction in traffic, it also led to a lasting change in the mobility preferences and needs of users. For example, the pandemic led to a permanent "decrease in the intention to use sustainable modes and a corresponding increase in using the car" (Sottile et al., 2024). In addition, the general willingness to share rides with other people also decreased (Mohammadi-Mavi et al., 2025). These developments revealed not only the fragility of the transportations system but also its potential for adaptation. This thus highlighted an opportunity to rethink mobility practices at the individual and systemic levels.

Despite growing recognition of these challenges, there remains a gap in understanding how transport providers can actively shape this transition from their side. While previous studies have often focused on

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describing current mobility behaviors or approaching systemic transformations from a theoretical perspective, fewer efforts have been made to integrate empirical insights from practitioners with social science theories on technological acceptance and behavioral change.

In this context, the Ruhr Region in Germany serves as an illustrative case study due to its historically car-centric infrastructure and unique socio-economic dynamics (Melkonyan et al., 2020; Mubiru, 2025). Therefore, understanding how transport companies and public authorities in this region operate and interact can provide insight into the general mechanisms of the transport system. Here, it is particularly interesting how these actors encourage sustainable mobility behavior while adapting to these pressures.

This paper seeks to address these points by examining how public authorities and transport companies perceive their role in promoting sustainable mobility behaviors within the Ruhr Region. Specifically, it investigates the following questions:

1. How do these stakeholders view their ability to influence customer willingness toward more sustainable travel options?
2. What strategies are being employed or envisioned in response to changing societal needs, environmental pressures, and technological advancements?
3. What challenges arise from the associated interaction between different levels of governance?

A key contribution of this study lies in its focus on actionable insights derived from practice-oriented perspectives. By combining guideline-based expert interviews with representatives from various sectors and governance levels of public transport in the Ruhr Region with established social science theories, this research aims not only to describe current challenges but also identify concrete starting points for fostering behavioral change.

Following this introduction (Section 1), Section 2 provides an overview of relevant theories that form the foundation for this work and reviews prior studies on mobility behavior in Germany. Also, the Ruhr Regions transportation system and characteristics are elucidated here. The methodological approach is outlined in Section 3. The results are then analyzed in Section 4 and discussed, concluding with reflections on implications for policy and practice in Section 5.

Literature review

Theoretical foundations

Mobility in Sociology

Mobility is a multifaceted concept. This article focuses on the perspective of "circular mobility", i.e. "changes of location without a change of residence" (Manderscheid, 2022). More specifically on the perspective of mobility providers on their own corporate behavior as well as individual mobility behavior of public transport users.

From a sociological point of view, it is of particular interest to examine the contexts in which transport mode choice decisions are embedded, the role played by preferences and needs, and how this individual behavior interacts with provider-side system components as well as the social (sub)system of transport as a whole.

Theories of traffic control and mode choice

If passenger transport is considered as a socio-technical system, an understanding of the existing control structures is essential for an understanding of the system as a whole. Control can be defined here as "the intentional intervention in social systems with the aim of bringing about intended changes" (Weyer et al., 2013). It is therefore characteristic that this intervention is initiated by one or more controlling instance(s) and aims at changing the whole system or part(s) of it. Luhmann also sees control, figuratively speaking, as the "reduction of a difference" (Luhmann, 1994) between the desired target direction and the actual course. Control must be distinguished from coordination in that coordination is "decentralized and multidirectional". This means that it is not the intervention of a single actor, but rather a "mutual agreement between equal actors with the aim of achieving a solution to a problem that is viable for all participants" (Weyer et al., 2013).

Superior to these two terms is the concept of governance, which combines control and coordination in a (socio)technical system. Different types of governance can be distinguished, such as prohibition-based hard governance or incentive-based soft governance. Governance takes place on several levels: The highest level is the "level of coordination processes in negotiation systems (GOV-1)" (Weyer et al., 2013). At this level, in the transportation system basic regulations are negotiated between politics and stakeholders, which are then transferred to the "level of regulation of functional subsystems (GOV-2)" (Weyer et al., 2013) in the context of the respective subsystem, thus creating the framework for implementation. Here, the responsible organizations have the task of "translating political goals and measures into practicable standards and rules" (Konrad et al., 2020). The third level is the "level of operational control of the subsystem (GOV-3)" (Weyer et al., 2013). At this level, the aforementioned governance modes are then implemented in the form of concrete actions by transport associations and companies.

For this study, an examination of the latter, third level (GOV-3) and its interaction with the higher levels therefore seems particularly relevant. From a theoretical perspective, this is where the scope for action actually available to transport providers lies. These governance structures form the framework for creating mobility services, but they are often only viewed from the outside in prior mobility research. In this context, traffic figures are often considered in isolation from their sociological context.

In addition to an understanding of governance mechanisms, an understanding of the factors that influence the mobility behavior of users of a transportation system is necessary to understand the points at which providers can influence individual mobility behavior. Weyer and Hoffmann (2023) offer an explanatory approach that is based on Esser's (2000) subjective utility calculation and extends it to include factors of the social context. According to this approach, individual attitudes and preferences, together with the subjective perception of the situation and factors of the social context, are decisive for mobility behavior (see Fig. 1). The social context influences mobility behavior in two ways: On the one hand, as a set of objective factors (e.g., place of residence, individual socio-demographics or available means of transport). On the other hand, the subjective perception of the available options individually shapes decision-making.

In the context of mobility behavior, mode choice is initially determined by the prioritization of certain characteristics, such as speed or environmental friendliness, for one's mobility, as well as the subjective attribution of these characteristics to the respective means of

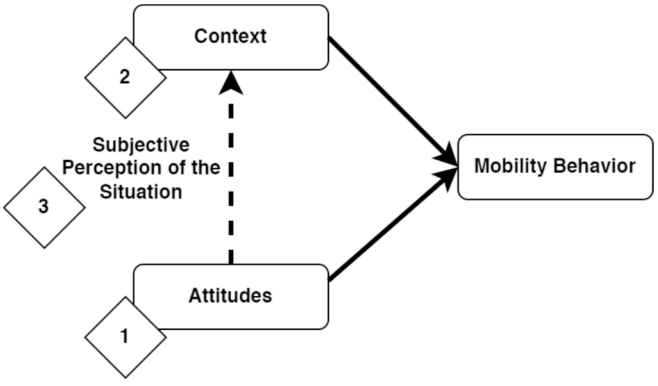

Fig. 1. Model of Mobility Behavior extended to include context factors (Weyer and Hoffmann, 2023).

transportation and the extent to which they are attributed. Some modes of transportation may be perceived as more or less useful for reaching one's destinations. The requirements for the chosen means of transportation may also vary; for instance, when transporting children. According to this model, the combination of three main factors—attitudes, subjective perception, and context—determines actual mobility behavior and, thus, the choice of transportation mode (Weyer and Hoffmann, 2023). Minnich et al. (2024) developed a similar utility framework in the context of mode choice. In this framework, they considered the various internal and external costs associated with using certain modes of transportation.

The Theory of Routine Mode Choice Decisions (TRMCD) by Robert Schneider (2013) offers another explanatory approach to mode choice. In his approach, Schneider draws on the Theory of Planned Behavior (Ajzen, 1991) and the Normative Decision Making (NDM) model of Schwartz and Howard (Schwartz and Howard, 1981), among others, to illustrate the importance of combining dispositional, habitual, and situational factors. Fig. 2 illustrates the decision-making process. This process begins with the physical and mental availability of a mode. Accordingly, users must be aware of the availability and characteristics of a particular mode at the time of decision. According to Schneider, the mental availability of a means of transport can increase when confronted with the option of using it in everyday life (Schneider, 2013).

The chosen mode of transportation must then satisfy a number of situational needs that can be understood as personal preferences: These include, for example, protection from criminal attacks on public transport, the accident safety of a car, but also the comfort, cost and perceived pleasure associated with using a mode of transport. A similar inclusion of individual preferences can also be found in the work of Adelt et al. (2018)[1] or Schmitt et al. (2018).

This subjective calculation of benefits represents an intersection with the previously described model of mobility behavior according to Weyer and Hoffman. According to Schneider, the final factor in the process of choosing a mode of transportation is routine. Users tend to make the same decisions under the same conditions if they have already chosen a mode for a particular route in the past. This means, for example, that people only question the bus route to work when the usual bus connection changes and thus becomes less favorable for their own calculations.

In such a case, decision-making switches from an automatically spontaneous mode to a (subjectively) rationally calculated mode (Esser, 1990; Kroneberg, 2007). While in the former mode the routine decision is not questioned, in the latter mode the subjective benefit is reassessed, which is an essential leverage point for motivators of mobility behavior (Kohaupt-Cepera, 2025). These findings can be further supported from a perspective of normative decision making: Klöckner and Matthies transfer the work of Schwartz and Howard (1981) into a mobility context and find that

> "if habits are strong the relation will be cut short and travel mode choice occurs according to existing schemata. If habits are weak a more deliberate norm-based decision is possible" (Klöckner and Matthies, 2004).

Such a questioning or deviation from the routine can therefore result from changes in the framework conditions. These changes can come from outside (as in the case of the addition or removal of offers) or from within (as in the case of a personal change of residence) (Verplanken et al., 2008).

In their study of the barriers and motivators of autonomous ride pooling, Studer et al. (2025) consider a variety of factors and use an extension of the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2012) as a foundation. They identify factors comparable to the situational needs described above as relevant. However, their work also shows that factors such as perceived control, social norms, and personal abilities are important as well. Thus, this study forms a link between mode choice and technology acceptance. The latter will be discussed in more detail in the next section.

Regarding the focus of this article, the aforementioned studies reveal several gaps in research that were not addressed: First, only the user side is examined. Therefore, it would be interesting to determine how mobility providers can identify and address their customers' situational needs and preferences. Additionally, it would be interesting to determine if there are opportunities for providers to increase the mental availability of sustainable transportation options. Furthermore, little research has been conducted on how the different levels of transportation governance interact with each other concerning their different perspectives on the system, as well as their distinct possibilities to influence users' decisions regarding mode choice.

Theories of technology acceptance

Park and Ha (2014) combine the Theory of Planned Behavior (Ajzen, 1991) with Schwartz's Norm Activation Model (1977) in a recycling context. According to them, both the subjective norm and the awareness of the consequences of a certain behavior influence the formation of an attitude toward the behavior, a perceived behavioral control, and a personal norm. These three factors, together with the subjective norm, then influence behavioral intention. What stands out in this model is the interplay between the two different types of norms: The subjective norm is constituted by social pressure, but in this model, it is additionally influenced by the individual's awareness of the consequences of the behavior. Both in the context of recycling studied by Park and Ha and in the context of transportation, this seems to be a useful extension of the model, especially since the choice of means of transportation is directly linked to consequences such as resource use or CO2 emissions.

In the transportation context, the work of Marcel Hunecke (2006) provides clear examples of the relevance of environmental responsibility norms in the transportation context. Additionally, Sottile et al. (2024) developed a hybrid choice model focusing on the relationship between social norms, behavioral intentions, and perceived behavioral control. They find that these factors influence acceptance of certain modes of transportation, especially in regard to the ease of using cars. They also confirm the assumption that external shocks, such as the pandemic, can have lasting effects on acceptance. This is mainly because such shocks can alter norms and perceptions, shifting priorities from one area to another.

From this article's perspective, these theoretical findings raise the question of the extent to which mobility providers can increase

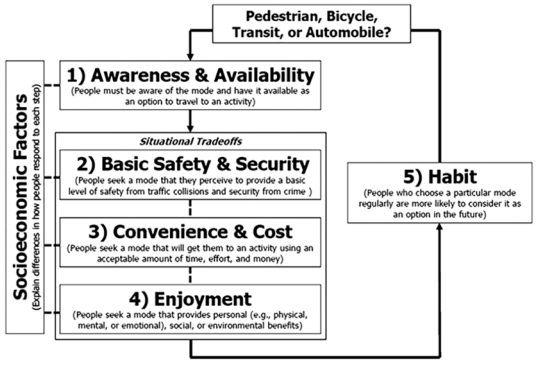

Fig. 2. Theory of Routine Mode Choice Decisions (Schneider, 2013).

[1] They design their decision model with reference to the individual prioritization of speed, comfort, safety, cost, and environmental friendliness.

awareness of the consequences of using certain means of transport. It is also necessary to determine how providers can shape social norms and address concerns regarding the fulfillment of these norms by public transport.

The Technology Acceptance Model (TAM) by Fred Davis (Davis, 1986; Davis et al., 1989) is also an adaptation of previous theories. It is based on the Theory of Reasoned Action (TRA) by Ajzen and Fishbein (Ajzen and Fishbein, 1980) and represents an adaptation of this theory to the context of the use of IT systems. This model also assumes that the intention to use is the central factor influencing the performance of a behavior or, in this case, the use of a specific system. Similar to the models presented above, this behavior is also significantly influenced by the attitude toward the behavior. The main difference from the previous models, however, is that the model focuses on perceived usefulness (PU) and perceived ease of use (PEOU). These can be influenced by external variables (such as perceived behavioral control) but are essentially made up of the individually attributed characteristics of the technology to be used.

In a transportation context, the TAM can also be used to study the willingness to change behavior. This has already been done in previous studies (Paddeu et al., 2020; Weyer and Cepera, 2022), where trust was identified as another key factor. Aasvik et al. (2025) also confirm the role of trust in the context of acceptance of mobility solutions. They also establish a link to the previously discussed factors of perceived benefits and situational needs (in this case, hedonic motivation). This further highlights the connection between the constructs assumed as a basis here, but once again places the focus on the user side.

Several other prior studies (e.g., Kaye et al., 2022; Harkin et al., 2025) have also discussed the application of this model to a transportation context. However, these studies also focus on the user side, identifying various factors involved in technology acceptance. They rarely delve into how to increase acceptance on the part of the provider. Therefore, it is particularly interesting to determine how mobility providers can apply these scientifically established findings. It is also important to determine whether they are aware of these mechanisms and if they are incorporating them into the design of their services.

Theories of technological transformation

Technological transformation can be viewed from several complementary perspectives: Tushman and Rosenkopf (1992) describe technological change as the product of a community and divide it into a four-stage cycle of variation, fermentation, selection, and retention. Holling (2001) also sees transformation as circular. In his view, it is the result of an adaptive cycle of recurring negotiation processes through which a system moves between different stable states. If the system becomes unstable or loses its adaptability due to internal dynamics, this creates an openness to external influences. According to Holling, external influences can lead to discontinuity and then to transformation: They lead to a release of resources, which leads the system into a phase of reorganization and thus enables a new run through this cycle. In this context, Frank Geels also sees external environmental influences that have a shock-like effect on systems as favorable factors for a sustainable transformation of these systems (Geels, 2010). He refers to both approaches described above and combines them with the logic of the multilevel perspective (Geels, 2002, 2006). It summarizes technological change on three central levels: The technological niche, the socio-technical regime, and the landscape that forms the cultural and institutional framework.

Regarding the landscape of the transportation system in the Ruhr Region, the most obvious example of a disruptive external influence is undoubtedly the COVID-19 pandemic as mentioned before (although other potential risk factors, such as flooding, also exist.) In the short term, the pandemic led to a radical change in the choice of transport mode (Weyer, 2022), which can be explained by a spontaneous change in subjective utility calculations (Sinus-Institut, 2020). However, there are also long-term consequences for the transport system: the flexibilization of work locations, the increase in communication via videoconferencing as well as an increase in demand for individual transport have permanently changed both the options and the preferences regarding the use of transport (Sottile et al., 2024).

Regarding the socio-technical regime of public transportation in the Ruhr region, Mubiru (2025) found in his document study comparing different regions in Germany that public authorities are making efforts to integrate mobility as a service (MaaS) services into public transportation. However, coordination problems on the provider side and acceptance issues on the user side have so far hindered this process. For this reason, he proposes an integrative framework between public authorities and private providers. This implies the need for research into how various actors at different governance levels coordinate with each other, as well as the perceptions of the system that inform their actions.

Studies on mobility services and mobility behavior in Germany

According to Hagen and Reinfeld (2021), the studies "Mobility in Germany", the "German Mobility Panel" and "Mobility in Cities" provide an overview of the most important key data on mobility in Germany. Since the aforementioned studies also focus mostly on individual mobility behavior itself, this chapter summarizes and discusses relevant findings of different editions of said studies and supplements them with the provider perspective. To this end, findings from reports and statistics published by the Association of German Transport Companies are incorporated into the broader study context.

Mobility in Germany (MiD)

This study shows that people living in metropolitan regions such as the Ruhr Region "need on average a quarter of an hour more to cover their daily distances" (Nobis and Kuhnimhof, 2018). These figures have not yet been published for the latest edition of the study, so a definitive assessment of recent developments is not possible. However, the figures already shown for the overall average travel time suggest that little has changed between 2017 and 2023. This is particularly interesting, considering that the number of daily trips and kilometers traveled has decreased in metropolitan areas during the same period. Additionally, car ownership increased slightly between 2017 and 2023. Since then, more people have reported never using public transportation. This is exacerbated by the fact that the share of motorized individual transportation in the modal split remains significantly higher in the Ruhr region than in other metropolitan areas (Follmer, 2025).

One possible explanation for this special situation in the Ruhr Region is the different ways in which users' subjective benefit calculations are fulfilled in the context of the different modes of transport: In the cities of Dortmund, Essen and Duisburg, for example, the ADAC Mobil in der Stadt monitor ranks car satisfaction higher than that of public transport or bicycles (ADAC, 2017). In addition, public transport in metropolitan areas sometimes reaches its capacity limits and operators have to cope with large peaks in demand (Resch, 2015).

In the context of this article, these findings reveal the need for research on how mobility providers can address the strong presence of motorized individual transportation in the Ruhr region and the expected future transformations. First, it is interesting to consider the potential starting points and levers of the individual governance levels through which providers can influence the transport system. On the other hand, it is also important to determine their understanding of their position and tasks within the system.

German Mobility Panel (MoP)

Data from the German Mobility Panel shows a similar picture to the MiD study regarding mobility options: there is a "supply gap between urban and rural areas" (Vallée et al., 2022), which means that the private car is the main mode of transport, especially in cities with less than 20,000 inhabitants.

According to this study, travel time has returned to a level similar to

that before the pandemic. In 2022, respondents spent an average of 77 min (also a similar result to MiD) per day on mobility, 16 of which were spent on public transportation and 32 on private transportation, twice as much (Ecke et al., 2023).

These results show that providers of public mobility solutions need to focus on coverage in rural areas and travel times. Therefore, it is essential to research the provider perspective and approach with respect to these factors. This is because there has not been enough research on the extent to which factors such as public transportation coverage are within providers' spheres of influence. It is also possible that governing bodies not bound by providers' instructions are responsible.

Mobility in Cities (SrV)

The Mobility in Cities study examines mobility by city groups which "combine cities with similar characteristics (centrality, population, topography)" (Gerike et al., 2020). This study is therefore interesting because it allows for a targeted examination of the Ruhr region at the municipal level.

Even within large cities in the Ruhr Region and neighboring cities in Northrine-Westfalia, there are significant differences: While 77.8 % and 79.4 % of households in Duisburg and Bochum, respectively, own a car, this figure is only 66.1 % in nearby Düsseldorf, the capital of North Rhine-Westphalia. Conversely, 29.8 % and 37.2 % of people in Duisburg and Bochum, respectively, hold public transport season tickets, while 49.8 % of people in Düsseldorf do (Hubrich et al., 2025). This of course is only a selection of the key figures collected. However, it is also representative of the other trends between these cities such as the modal split or car usage.

These findings highlight the need for research into the reasons behind these differences from the providers' perspective, particularly at the operational and regulatory levels, given that these are essentially comparable cities in similar local contexts. The exact process of coordination between the various cooperating providers and the extent to which services are adapted must be clarified. This is particularly important because public transportation in the Ruhr region is decentralized, especially at the operational level (GOV-3).

Association of Transport Companies (VdV)

The German Association of Public Transport Companies (VDV) publishes several types of publications, including annual reports and statistics. While the annual reports focus on strategic issues related to public transport, the statistics provide an overview of the development of key figures in the sector. These publications can be seen as an example for a feedback mechanism between the governance levels mentioned in section 2.1.

For the purposes of this article, the last two annual reports (Verband Deutscher Verkehrsunternehmen, 2023a; Verband Deutscher Verkehrsunternehmen, 2025) provide the following findings in particular: For example, the experience with the 9-euro ticket highlights the regional differences mentioned in the last section. These make "an expansion of public transport urgently necessary, even in times and areas where demand is dispersed" (Verband Deutscher Verkehrsunternehmen, 2023a). In particular, on-demand solutions are mentioned as a possible solution, which are seen as a suitable complement to a future improvement of rail and bus lines. These solutions also seem to make sense because demand can fluctuate not only in space but also in time (Verband Deutscher Verkehrsunternehmen, 2023a). This includes both peak periods and seasonal variations. Both types of fluctuations could be addressed with on-demand services. Additionally, providers recognize the need for political action in rail transportation. The current system is unable to meet current demand, let alone allow for future expansion (Verband Deutscher Verkehrsunternehmen, 2025).

According to the latest VDV statistics (2023b), the number of passenger kilometers traveled on public transportation had already surpassed pre-pandemic levels by the time of the survey. North Rhine-Westphalia, in particular, had a notably high volume of traffic. At the same time, the number of passengers remained slightly below pre-pandemic levels but grew rapidly in large cities. Public transportation revenues also did not quite reach pre-pandemic levels during the survey period (Verband Deutscher Verkehrsunternehmen, 2023b). It hence is further becoming clear that the pandemic has had lasting effects, leading to a shift in transportation toward fewer mobile people who are, however, traveling longer distances.

These findings indicate a need for research into how providers in the Ruhr region will address the described developments and changes. This is particularly interesting in terms of the financial situation, but its significance goes far beyond that. After all, it signifies a fundamental shift in the demands customers place on mobility providers. It is therefore also interesting to see how the operational level (GOV-3) will interact with the other two levels in the future in order to contribute to a coordinated transformation of the entire system.

The Ruhr Region's transportation system

The transport network of the Ruhr region extends between Hamm in the west and Wesel and Duisburg in the east. Fig. 3 shows the Ruhr region's transportation network.

It should be noted that the Ruhr region has a dense network of roads and railways connecting its closely spaced major cities. Although there is a correlation between infrastructure and population density, the entire area is well-connected. These conditions make the special features mentioned earlier in this section even more interesting because the infrastructure suggests that public transportation should play a much greater role here.

Therefore, it is necessary to study the reasons for the differences in the prevalence and acceptance of public transportation from the providers' perspective and how these reasons can be changed. Although initial developments toward MaaS can already be observed, studies to date indicate that innovative mobility solutions have not yet played a significant practical role.

Section 2 explained the theoretical foundations, put current studies into context, and identified research gaps. The following chapters focus on the interview study conducted for this article.

Study design and methodology

The study conducted for this article is based on seven guided expert interviews with representatives from different transport institutions. These interviews were recorded, transcribed, and analyzed in a content structuring qualitative content analysis according to Kuckartz (2018) using MaxQDA.

Workflow

The workflow was structured so that the interviewees were first selected based on the literary findings from chapter two, and then the interview guide was developed. This process will be described in more detail throughout this section.

From a methodological point of view, the interview guide served as a type of a priori category formation (Kuckartz, 2018). These initial, deductive categories formed the basis for the text analysis of the interview material.

Fig. 4 shows Kuckartz' and Rädiker's overview of the workflow of a content structuring qualitative content analysis. The process begins with the initial text work, i.e., once the interviews have been completed and transcribed. First, the important passages are identified, and then the main thematic categories are formed along the material in a second step (see 4.3).

Step 3 involves coding the entire material using these categories. To better illustrate the whole process, the main category "new mobility" will be taken as an example, whose significance for this study is easy to understand. Consequently, all passages in all interviews that refer to new mobility were marked.

Fig. 3. The Ruhr Region's transportation network (map data from openstreetmap.org).

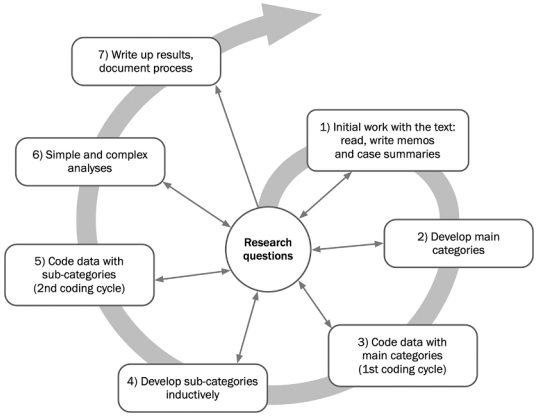

Fig. 4. Process of a structuring qualitative content analysis (Kuckartz and Rädiker, 2023).

In step four, the categories were sorted and differentiated into subcategories. For example, the relevant text passages on new mobility were examined in greater detail throughout the material. This revealed that there was talk of possible future developments and services in the context of new mobility. On the other hand, discussions about future-relevant sustainability strategies and the long-term transformation of the entire transportation system were also found. Consequently, these disparate passages were differentiated into the three subcategories "Future Mobility," "Sustainability Strategies," and "Long-term Mobility Transformation."

This differentiated category system was then used in Step 5 to code all the material with this level of detail. This completed the coding process, enabling analyses and visualization in step 6 as well as writing up the results during the final step, number 7. These analyses involved a category-based evaluation of the main categories, followed by an analysis of the relationships between the categories. The analysis of relationships was based on the proximity of codes within the text and mapped using similarity matrices, as in multidimensional scaling (Backhaus et al., 2015).

To improve conciseness, the relations of the three most frequently occurring[2] subcodes were examined for each main category. Pairs of subcodes were considered related if they appeared in the same text passage — that is, in the same speech turn by an interviewee. When examining the relations of the three most common subcodes in this main category, connections to other codes within the same category naturally emerge the most followed by relations with codes of other categories. Therefore, the evaluation focused primarily on the three most related topics outside the same main category and summarizes corresponding codes.[3]

Using the example of new mobility, this means that we first analyzed which detailed topics (such as the integration of new offerings into existing ones) appeared in the main category and how often they were mentioned. This was followed by an analysis of the intersections with other codes in the same and other main categories in the manner described above. These results are reported in Chapter 4.

Interviewee selection

In selecting the interviewees, the focus was on including as many different provider perspectives on public transport as possible in the survey. The aim was to capture perspectives from different levels of governance (see section 2) and, within the operational level, from

[2] If ranks 1–3 were occupied by multiple subcodes, more than three subcodes were considered accordingly.

[3] More detailed code relation tables that show all relations and their weights can be found in the Appendix.

different transport operators.

Table 1 provides an overview and numbering of the interview partners recruited for the survey, including their allocation to the different levels of governance. In particular, it can be seen that all levels were covered by the selection of interviewees. The type of company also shows that conventional transport companies, transport associations and also providers of new mobility services are represented. Conventional in this context means public transport by bus and train, new means individual sharing services. The operational level (GOV-3) is the focus of the survey because it is the central interface between providers and users. Consequently, this is the level that is most frequently represented in the selection of respondents.

Conception of the guide and the main categories

The interview guide was designed in 2020 and the interviews were conducted in the first half of 2021. Hence, it made sense to examine the effects of the pandemic from the perspective of the transportation providers, in light of the theories of technological transformation discussed in Section 2. After all, the temporary suspension of many transports and the resulting strong change in demand represented a discontinuity or a shock to the existing transport system, which could lead to a change in this system. The first topic of the guide[4] is therefore mobility and corona. The focus here is on how respondents would describe the situation in their company before the restrictions imposed by the pandemic and what has changed as a result of said restrictions.

Since the focus of this article is on the provider's perspective on the transformation towards more sustainable services and routines, related topics form the core of the guide and the survey. In public transport, this may take the form of new services or fare structures, which in turn change the availability or utility of certain means of transport for users (Schneider, 2013; Adelt et al., 2018). Additionally, it can be argued that the use of new technologies by providers, whether in the operation of existing vehicles or in the creation of new services, depends on similar factors as their acceptance by users. Accordingly, the differences are primarily a matter of context and frame of reference: For example, while users are concerned with the cost-effectiveness of a single trip, providers are concerned with the cost-effectiveness of the entire transportation operation.

Accordingly, the following two topics of the guide are theoretically closely intertwined: sustainability / modal split. Here, the focus is on how providers view sustainability, which sustainable mobility measures they have already taken and to what extent, and which are currently planned. In this context, it is particularly interesting to know which concept of sustainability prevails in provider's views. It is also of interest whether explicitly sustainable offers are better accepted by users than conventional offers and which factors providers consider relevant for acceptance.

Table 1
List of interviewees.

Interviewee	Company Type	Governance Level
I1	Transport Operator	Operators (GOV-3)
I2	Mobility Blog	Politics and Interest Groups (GOV-1)
I3	Municipality	Responsible Bodies (GOV-2)
I4	Transport Association	Operators (GOV-3)
I5	Carsharing Operator	Operators (GOV-3)
I6	Bike sharing Operator	Operators (GOV-3)
I7	OEM of Autonomous Vehicles	Politics and Interest Groups (GOV-1)

[4] The guide used for the interviews can be found in the Appendix.

The third topic of the guide is new technologies. The focus here is on the attitude of service providers themselves towards new services such as ridesharing and new propulsion technologies. Of particular interest are the challenges and obstacles that need to be overcome to achieve more sustainable mobility.

The last block of the guide is called Mobility Needs. The focus here is on the methods of needs assessment and mobility planning on the part of providers, as well as the question of how user preferences are collected and integrated, and what possible future scenarios for service structures could result from this. Following the above, Table 2 provides a summary of the topics of the guide, as well as their respective emphases and theoretical references.

Table 3 shows an overview of the main categories. These differ from the guide's topics because the initial work with the interview material revealed a need to expand and restructure the main categories: The description of new mobility services was often accompanied by an explanation of the initial situation to be changed, so a category was introduced in the coding for those text passages dealing with descriptions of current mobility services and service structures.

It also became clear that many of the decisions made in the companies surveyed are linked to local conditions, laws or regulations and should not be considered in isolation. As a result, an additional category was introduced for government, technical, and economic framework conditions. In addition, a new category has been added that specifically addresses the provider-side factors that influence the mobility behavior of users, as these may differ from the needs surveyed and the actual mobility planning or may even precede it.

Results

The evaluation of results is based on the order of the main categories introduced in the previous chapter.

Table 4 provides an overview of the number of coded items and the number of subcodes and subcategories assigned. It is noticeable that the first two categories were mentioned visibly less in the interviews than the others. It is also noticeable that Framework Conditions is a category with many coded text passages, even though it was not specifically asked about in the interviews. This shows the great importance of the institutional framework and is in line with previous studies that have examined its role in system control and behavior change (e. g. Weyer et al., 2018; Weyer and Cepera, 2022).

In the following sections, the subcategories will first be evaluated along selected passages and then the code-subcode models and code relations identified will be reported. It should be noted that the quotes from the respondents presented in the evaluation are representative of the underlying categories. These quotes were selected to reflect specific focal points of the respondents' original words. However, the core of the analysis lies in the category system itself.

Fig. 5 provides an overview of the first two levels of the category system and illustrates the overall relationships of these two top levels. Detailed code-subcode models of the levels below are found at the end of the subsequent sections, which are structured according to the categories in this overview. These models then demonstrate the relationships between the codes in the overview and their respective subcodes.

Table 2
Topics of the guide.

Topic	Focus
Mobility and Corona	Changes in demand and needs between normal andcrisis mode, aftereffect of the pandemic
Sustainability and Modal Split	Development and acceptance of a sustainable supply, incentives for sustainable mobility practices
New Technologies	Provider attitudes toward new technologies andmobility services
Mobility Needs	Methods used by providers to assess needs and plan mobility, potential future scenarios and user preferences

Table 3
Overview of the main categories.

Number	Main Category	Description
1	Mobility and Corona	This code identifies passages that explicitly deal with the comparison between normality and crisis mode as well as aftereffects in the context of the pandemic.
2	Current Mobility Services	This code identifies text passages related to the respondent's existing services and previous scope of work.
3	New Mobility	This code refers to text passages that deal with new and sustainable technologies and new mobility services, as well as attitudes towards them and mobility behavior. This includes (sustainable) changes to conventional services such as public transport and cars.
4	Mobility Behavior	This code identifies text passages that mention characteristics and factors influencing user mobility behavior from the provider's perspective.
5	Mobility Planning and Needs	This code identifies text passages that deal with mobility planning (supply or demand oriented), related future scenarios and preferences.
6	Framework Conditions	This code refers to text passages that express the provider's view of existing political and legal frameworks and their long-term changes.

Table 4
Overview of the Number of Coded Passages and Subcategories.

No.	Main Category	Number of Coded Passages	Number of Subcategories	Number of Subcodes
1	Mobility and Corona	43	2	14
2	Current Mobility Services	43	2	10
3	New Mobility	145	3	27
4	Mobility Behavior	102	4	22
5	Mobility Planning and Needs	118	3	24
6	Framework Conditions	92	3	22

Furthermore, the thickness of the arrows in the following code-subcode models indicates how frequently individual subcodes occurred.[5]

Thus, the explanations outside the quotes in the subsequent sections refer to the entire category system, not just the quoted text. This approach was chosen to comply with Kuckartz' "call for a supplementary case orientation" (Kuckartz, 2019). To this end, an analysis of the distribution of categories across cases and governance levels is also included at the end of the results chapter.

Mobility and Corona

The statements made by mobility providers about the impact of the pandemic can be divided into two subcategories: The first subcategory is the change in users' mobility behavior that providers have observed as a result of the pandemic (4.1.1). Accordingly, this change could also be described as an indirect effect of the pandemic on transport companies. The second subcategory contains the direct impact of the pandemic on transport companies (4.1.2).

Change in users' mobility behavior

With regard to changes in mobility behavior (4.1.1), respondents first mentioned two basic phenomena: the decline in the use of public transport during the lockdowns and the resumption of its use when the lockdowns were lifted.

The decline in public transport and sharing use not only required transportation companies to plan their operations differently, but also to approach their customers in a new way. As a result, transport companies needed a way to communicate with customers who were no longer using public transport regularly due to the pandemic and were therefore not up to date with the latest information.

> "If you don't use public transport regularly, you also lose the competence to use it." (I1)

For example, one interviewee reported that customers need regular contact with public transport in order to be informed about current developments in the traffic situation, closures or fare changes. Moreover, if the continuity of such routines is not guaranteed by regular use, transport companies need to adapt their information policies accordingly. The same may become true if people no longer commute to work every day due to increased mobile working.

> "We always knew we would lose passengers to the home office eventually, but we didn't expect it to happen to such an extent in such a short time." (I1)

It is precisely this mobile work that is one of the most important factors influencing customers' mobility behavior after the pandemic. In addition to the mere decrease in mobility, transport companies also observed a shift towards individual transport: both private alternatives such as personal bicycles and commercial alternatives such as bike or scooter sharing became more popular during the pandemic. Fig. 6 provides a graphical summary of all codes recorded in relation to the change in user's mobility behavior and their frequencies. It underscores that the decline in demand for public transport was by far the most frequently mentioned factor. Together with changes in preferences, this was therefore the key indirect factor.

Direct impact of the pandemic on transport companies

The decline and change in the use of mobility services made it particularly difficult for new companies to survive in the market. However, established companies were also weakened beyond the decline in their revenues: Recently launched products could not be properly evaluated, planned launches of new products were delayed, and the suitability of new products under the new conditions was unclear.

> "It affected us to the extent that we actually delayed the release a couple of times because we said, yeah, releasing a mobility platform during a lockdown is a very bad time." (I3)

In this context, one interviewee working for a municipality reported that the entire rollout of a newly developed mobility platform was postponed several times due to the influence of the pandemic. This shows the extent of the impact, but also, from a control perspective, that all levels of governance are affected.

For the transport companies, however, there were also some positive effects: The sudden change in framework conditions disrupted routines not only for users but also for employees, creating opportunities for transformation. This allowed them to think more freely about future mobility services and begin new cooperations. Fig. 7 provides a graphical summary of all codes recorded in relation to the direct impact of the pandemic on transport companies and their frequencies. This highlights that, in terms of direct influences, the effects on new companies dominated the respondents' perceptions.

Code relations

Overall, there are clear links to codes related to individual transportation. For instance, the code indicating a decline in public transportation usage was often used alongside the codes "limitations of conventional means of transportation," "limitations of non-MIT solutions," and "aversions against public transport." This goes hand in hand

[5] Detailed numeric frequency tables showing the distribution of individual subcodes can be found in the appendix.

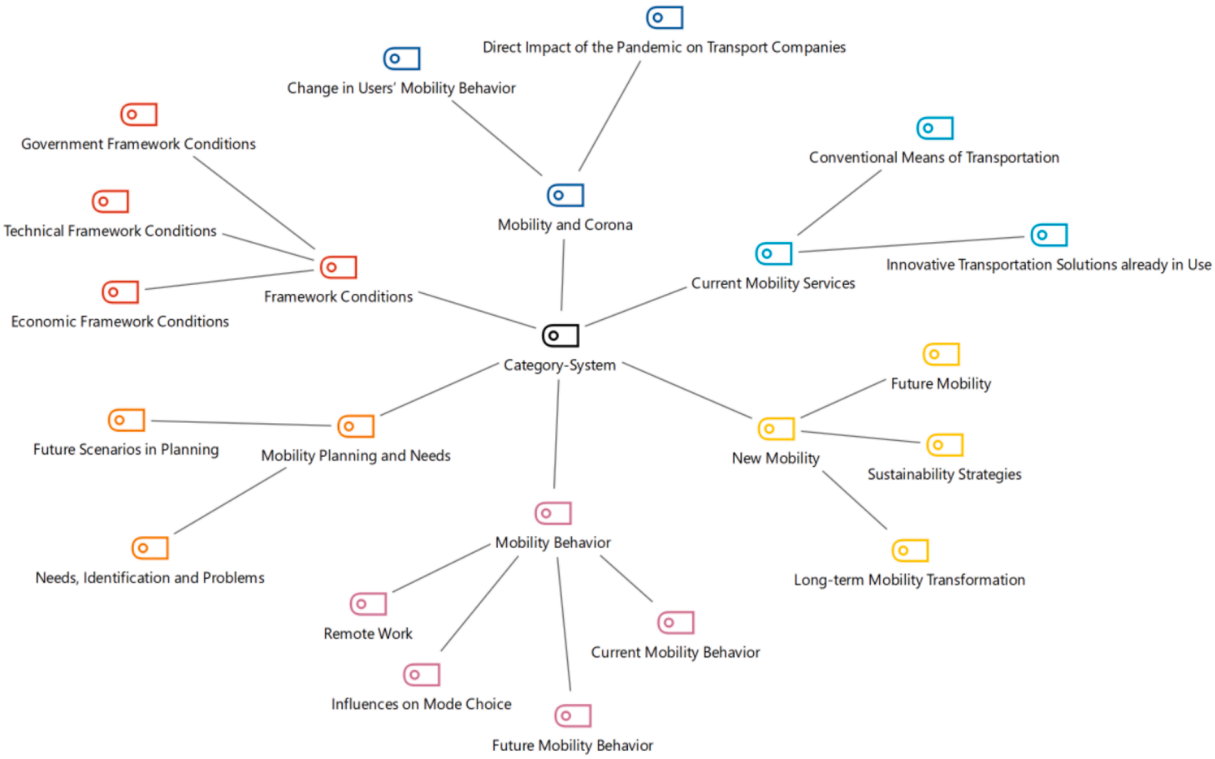

Fig. 5. Overview of the Category System.

with respondent's statements about the shift of preferences towards hygiene among users.

Furthermore, the unique circumstances of the pandemic have amplified problems inherent in the current financing structure of public transportation.

Finally, the increase in mobile work was frequently mentioned in connection with the codes in this main category, whereby, according to the interviewees, the pandemic can be seen as the trigger, but not the end point of this development.

Current mobility services

The main category, which summarizes respondents' statements on the topic of current mobility services, can be divided into two intertwined subcategories: Conventional means of transportation and their use (4.2.1) and innovative transportation solutions already in use (4.2.2).

Conventional means of transportation

Regarding the subcategory of conventional means of transportation (4.2.1), many of the respondents' statements focus on the limitations of conventional transport and the decentralized structure of public transport. Conventional means of transportation are often underutilized, which can be observed for both public transport and cars.

The low use is accompanied by an unnecessarily high demand for space and infrastructure, which leads to competition between different modes of transport, for example, when cyclists, buses and parked cars compete for road space. In this context, providers see motorized individual transport (MIT) in particular as a problem factor that severely restricts other means of transport. Conventional public transport is also inflexible in terms of frequency and capacity, making it difficult to respond to short-term changes in demand. From the provider's point of view, this leads to the need for long-term planning, which makes the entire conventional public transport system inflexible.

The financial limitations of public transport should also be mentioned: According to the interviewees, the main problem here is that public transport is often expected to make a profit while at the same time fulfilling the function of a social service of general interest. According to the interviewees, public transport is at best profitable when its effects on the surrounding economy are taken into account, but not independently, so that subsidies are generally necessary. However, regarding subsidies, public transport competes with other urban needs, such as the need for new educational facilities.

The organizational structure of the current public transport system is another issue that has been raised several times: the fact that coordinated services and timetables are also needed between municipalities, especially in conurbations, is a key issue. This often has to be coordinated between transport associations and individual transport companies, as public transport currently has a decentralized structure. Fig. 8 provides a graphical summary of all codes recorded in relation to conventional means of transportation and their frequencies. It shows that the respondents' statements primarily highlighted the limitations of conventional modes of transport in terms of flexibility and individuality.

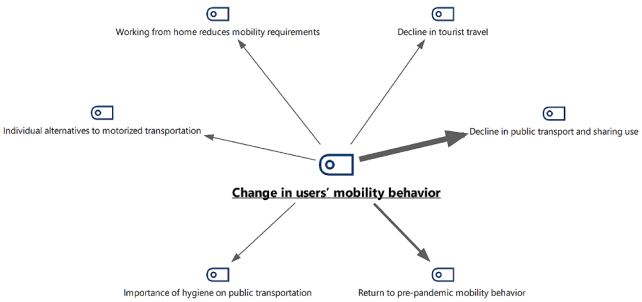

Fig. 6. Code-subcode model for change in user's mobility behavior.

Innovative transportation solutions already in use

Regarding innovative solutions already in use (4.2.2), different sharing services and their integration into intermodal and multimodal services are discussed in particular. In a metropolitan region such as the Ruhr area, for example, car, bike and scooter sharing services are already available in many cities.

> "It's not yet recognizable as a continuous route, so you can enter it into the app, from A to B, and then it suggests the bus and the last part by bike." (I.2)

According to the interviewees, the main common standpoint is that these services are to be seen as complementary to traditional public transport services. This is reflected in the fact that current intermodal mobility offers often make a core service bookable and plannable, while information on possible add-ons such as rental bicycles or scooters is displayed but cannot be booked together with the core service.

Finally, the ambivalent position of on-demand transport should be mentioned at this point: on the one hand, this represents an innovative transport solution when controlled algorithmically in real-time, but at the same time, according to the interviewees, it has already been established for some time in the form of cabs and on-demand buses. The distinctive factors here are therefore the underlying routing method as well as the booking process itself. Fig. 9 provides a graphical summary of all codes recorded in relation to innovative transportation solutions

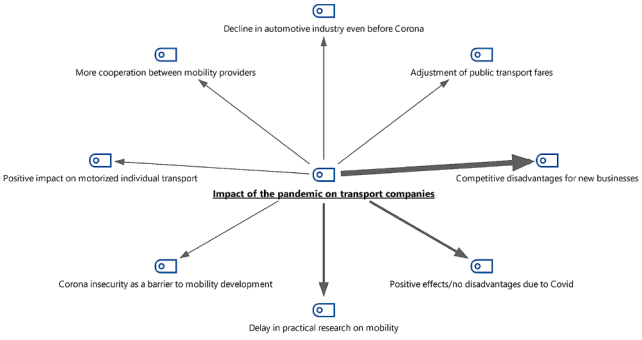

Fig. 7. Code subcode model on the impact of the pandemic on transport companies.

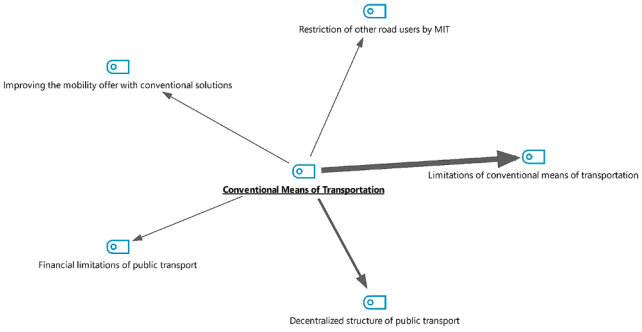

Fig. 8. Code subcode model on conventional means of transport.

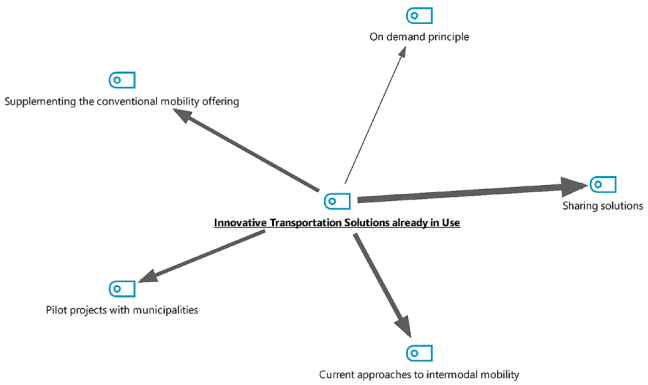

Fig. 9. Code subcode model for innovative transportation solutions already in use.

already in use and their frequencies. Sharing solutions and the current state of intermodality were the predominant topics here.

Code relations

Examining the relations between the most common subcodes in this category and other codes reveals two noteworthy areas: First, the relevance of cars in the context of current mobility services was mentioned particularly frequently. This is understandable, as the interviewed providers repeatedly mentioned the limitations of conventional public services compared to motorized individual transportation.

On the other hand, the need for a holistic transformation of the transport system was repeatedly pointed out in context with current services. This refers to both the transportation infrastructure itself and the creation of new, demand-oriented services, as well as the infrastructure for planning and booking. In this context, the possibility of transforming the current ownership infrastructure through urban mobility structures was also discussed. This will be explained in detail in 5.3.

New mobility

The statements of the respondents that can be assigned to the New Mobility category can be divided into three subcategories: The first subcategory includes statements dealing with future mobility (4.3.1) and thus its design and implementation. The second subcategory contains statements dealing with sustainability (4.3.2) and strategies to achieve it. Finally, the third subcategory includes statements that describe a long-term transformation in mobility (4.3.3).

Future mobility

Central issues in the area of future mobility (4.3.1) are primarily the creation and improvement of innovative mobility services, the limitation of solutions outside of private transport, and their integration into existing service structures.

In this context, it is striking that the interviewees almost exclusively talk about technical innovations: for example, the possibility of renting a bike via smartphone instead of an office-based rental, or free-floating car sharing instead of station-based car sharing. Bike parking facilities that can be booked via app and new drive technologies are also mentioned. This means that the interviewees initially refer to a purely technical concept of innovation, which must be distinguished from a social concept of innovation.

> "So far, on-demand services in Germany have all been designed to be an add-on to transportation." (I1)

The question of whether on-demand solutions are offered in a complementary or substitutive way is also important in the context of integration. One interviewee described that in the current situation, on-demand solutions are not intended to (even partly) replace traditional public transport solutions, although they would consider this to be necessary for efficient operation. At the same time, however, respondents do not envision a complete replacement of existing public transport with on-demand solutions, as on-demand solutions simply do not make sense, especially at peak times in congested areas. In addition, the sharing providers, which are mostly privately organized, are subject to strong market pressure.

> "So apart from the changes in propulsion, we haven't really had any innovations that have had a real impact on sustainability at a technical level." (I.2)

Similar to on-demand solutions, respondents also see difficulties in the widespread implementation of alternative drive systems. The problem is that large purchases of alternative-drive vehicles are currently associated with high financial risks. As a result, transport companies are making such purchases primarily because of possible government subsidies, but these are not sufficient for widespread use. On the transportation side, such vehicles also have their own requirements in terms of infrastructure and network planning, for example when it comes to range and charging points.

However, it should be noted that the respondents (especially in the field of public transport) have a very clear idea of a transformed transport system: Beyond vehicles and propulsion systems, mobility becomes a service that cities (and their transport companies) provide to their citizens. Some of the necessary components are already established in some places, but what is missing is the integration of these components into a singular service and a corresponding change in the way people use public transport services. Fig. 10 provides a graphical summary of all codes recorded in relation to future mobility and their frequencies. It is interesting to note that, in addition to the limitations of public transport already mentioned above, the focus was primarily on improving and integrating innovative solutions. This highlights the current shortcomings.

Sustainability strategies

With regard to the topic of sustainability (4.3.2), the interviewees presented a multi-faceted picture. While one interviewee sees the aforementioned change in drive systems as the only step taken so far, the other interviews reveal further dimensions: When it comes to ecological sustainability, for example, the interviewees see a picture that is detached from the private car and that supplements (or at times even

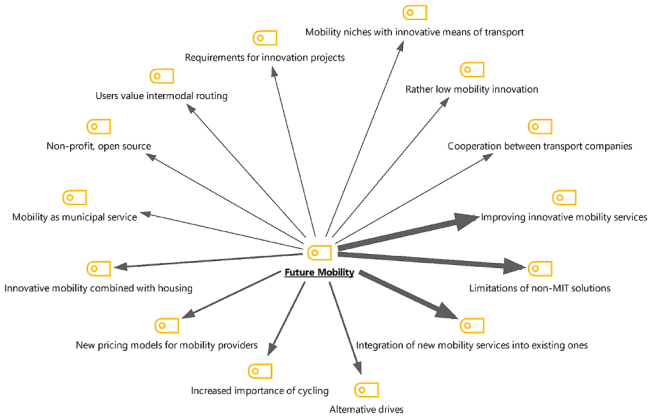

Fig. 10. Code-subcode model for future mobility.

replaces) classic public transport with additional components such as rental bikes and on-demand services, which should be plannable and bookable via an integrated platform.

In addition to the aspects already mentioned, a dimension of social sustainability also comes into play: In the interviews, representatives of public transport companies repeatedly refer to their function of public interest services and the need for non-discriminatory access to public transport. This view forms the basis for a vision of mobility as an urban service. In addition, several interviewees from different sectors advocate a user-centered development of the mentioned platforms. The aim is to achieve the lowest possible threshold of usability and comprehensive information. From the perspective of economic sustainability, as indicated in the last section, this means that public transport should not be considered in isolation, but always in a macroeconomic context. It should also be noted that some respondents believe that a targeted reduction of motorized individual transport is also necessary for a sustainable transformation. Fig. 11 provides a graphical summary of all codes recorded in relation to sustainability strategies and their frequencies showing the dominance of the topic of a intermodal booking platform or the need for it.

Long-term mobility transformation

With regard to the long-term transformation of mobility (4.3.3), there is a striking consensus among the respondents: the most frequently discussed point is the need for a holistic change in the transport system.

> "However, an exciting question is: Is it really just the next drive replacement […]?" (I.1)

In this context, the concept of innovation, which (as pointed out before) has so far been described as primarily technical, is broadened to the extent that, in addition to new technologies, infrastructural changes are seen as necessary in order to bring about a change in the transport system. In this context, the interviewees primarily addressed questions of spatial equity between different drive technologies, different modes of transport and the efficiency of the use of said modes of transport, since the public transport of the future should be able to react flexibly to changing needs.

Another important issue for long-term change, according to the respondents, is the social acceptance of new solutions, or even a conscious preference for those that can improve the sustainability of the transport system. This is relevant, for example, in the area of autonomous driving, as the diffusion of this technology is significantly influenced by its social acceptance. This also underlines the importance of attractive and needs-oriented design and user-friendliness of new services, beyond mere technical innovation, in order for them to be widely accepted.

Finally, it should also be mentioned that, even taking into account possible measures, fully sustainable mobility is not achievable, at least from the perspective of some respondents. Therefore, in their view a general reduction of mobility is also necessary in addition to the creation of new services and approaches, if this sector is to become more sustainable overall. Fig. 12 provides a graphical summary of all codes recorded in relation to long term mobility transformation and their frequencies. The focus here was on social acceptance of innovative solutions and an integrated, holistic transformation of the system and its structures.

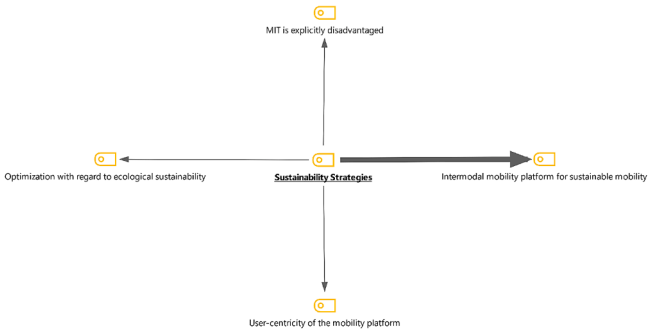

Fig. 11. Code subcode model for sustainability strategies.

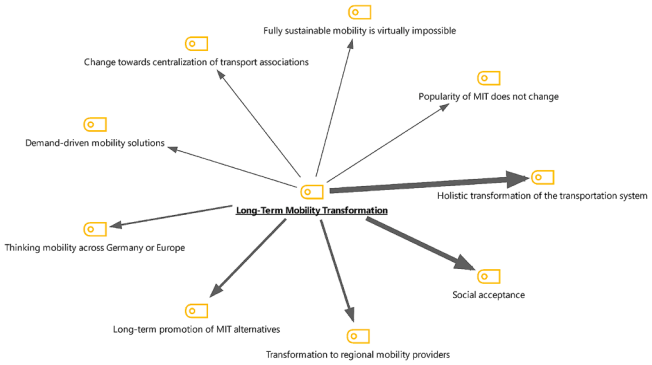

Fig. 12. Code subcode model on long-term mobility transformation.

Code relations

The relations between the most frequent codes in this category and those in other categories mainly revolve around shared mobility and mobility platforms. As the individual statements discussed above demonstrate, providers' expectations regarding future developments center on these topics. Accordingly, there are also relations to codes that address these topics from technical and regulatory perspectives.

There are also corresponding relations at the social level. Here, the focus is on acceptance of new solutions and the special social position of the car, including the resulting challenges.

Within this category, the relations focus on the user orientation of a potential mobility platform and on the need for a holistic transformation of the mobility system. This suggests that the respondents believe that future mobility will require not only changes in drive types or products, but also changes in social practices and infrastructure.

Mobility behavior

The statements evaluated in this section deal with the respondents' views on the mobility behavior of their customers. These statements can be roughly divided into four subcategories: Current mobility behavior (4.4.1), future mobility behavior (4.4.2), influences on mode choice (4.4.3), and remote work (4.4.4).

Current mobility behavior

The central theme of current mobility behavior (4.4.1) can be clearly seen in the following quote:

> "The fundamental question that arises […] is: How interested is the average person in intermodal travel chains and multimedia transport use when they still have the competing product of the private car?" (I.2)

Especially after the developments of the pandemic, the private car still occupies a central position in passenger transport, both in terms of transport share and symbolic value. For example, respondents mentioned that the competition between public transport and the car goes beyond the mere means of transport. Public transport has to contend with a poorer reputation, is viewed more harshly than the car when it comes to personal financial planning and requires more infrastructure. As a result, cars enjoy a high level of popularity, while public transport is mainly used when the user has no alternative.

In addition to this popularity of the car, there are also user aversions to public transport reported by respondents. These are, for example, reservations about the comfort or speed of public transport, which is considered to be inferior to the car in these dimensions.

> "Public transportation always has the smell of the proletarian vehicle." (I.7)

According to the respondents, users' resentment about status and prestige also influences their use of public transport. Other resentments that may be relevant to the choice of transport mode are, for example, a reluctance to use technical booking systems or concerns about privacy.

> "When we talk about modern or new modes of transportation, it is always implied that changing modes is not a problem. And we often get different feedback from customers." (I.1)

According to the providers, further restrictions in the choice or acceptance of transport modes result from the specific requirements of the route: Changing modes is generally unpopular with users, although changing modes is a necessary condition for intermodality. More precisely, according to the operators, changing is a problem especially when it has to be done close to the destination. This goes hand in hand with the statement that users prefer to use private transport, especially for the first and last mile. In order to achieve the highest possible acceptance of intermodal solutions, this means that offers that include an individual solution at the beginning and end of the trip chain are better accepted.

It is also interesting to note that, according to the respondents, environmental sustainability does not play a decisive role in their customers' choice of transport mode. This is true for both public transport and car sharing. For public transport providers, issues such as economy, maintenance intervals and suitability for the routes offered are also decisive for the choice of vehicles used. Car sharing providers report that they have not noticed a preference for electric vehicles among their customers. In addition, the average fuel consumption of car-sharing vehicles does not indicate a particularly ecological driving style on the part of customers. One exception to these findings is the popularity of bicycles, as evidenced by increasing sales and demand for bicycle transportation. Furthermore, differences in environmental awareness can only be observed in urban contexts, while in rural areas the need for sufficient mobility continues to dominate. Fig. 13 provides a graphical summary of all codes recorded in relation to current mobility behavior and their frequencies. As in the interviews themselves, the enormous social relevance of the car stands out here.

Future mobility behavior

With regard to future mobility behavior (4.4.2), providers see an increasing demand for real-time traffic data, both on their side and on the side of the customer. This can have an impact on mobility behavior, for example, by allowing a better estimation of the duration of a connection and the choice of the appropriate means of transport.

In addition, respondents see intermodal services as a direct

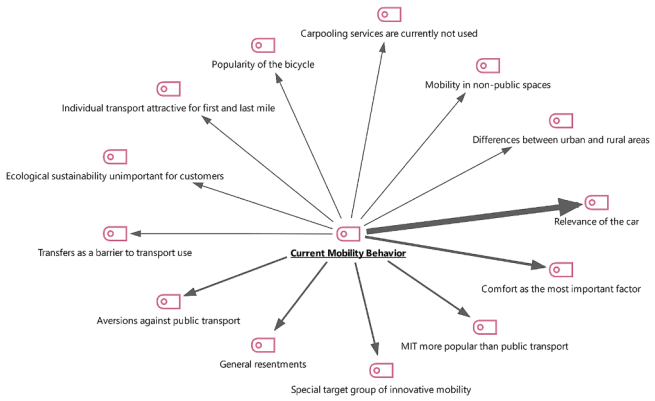

Fig. 13. Code subcode model on current mobility behavior.

competitor to the private car. On the one hand, they see shared cars as positive from their point of view, but on the other hand, they question the extent to which intermodal services are truly competitive, given the customer preferences for convenience described above. In their view, this competitiveness could be particularly threatened if the private car remains comfortable and affordable in the future. Fig. 14 provides a graphical summary of all codes recorded in relation to future mobility behavior and their frequencies frequencies underscoring the mentioned developments.

Influences on mode choice

In the context of the influences on the choice of transport mode (4.4.3), providers consider two points to be particularly important: the perception of the costs associated with the choice of transport mode and the visibility of alternatives, especially in the area of public transport.

These two points are closely related, as the subjectively perceived financial costs are paradoxically often estimated to be lower than the actual costs of traveling by car. As a result, the benefits of using public transport remain hidden behind this misperception, thus reducing its visibility. This is also seen by respondents in the relevant sector:

> "When I look at the minimum monthly cost of the smallest car, any public transportation ticket is cheaper. But that doesn't count at this point." (I.1)

As a result, public transport operators face the challenge of explaining the benefits of their products to their customers in the face of these prevailing perceptions. Fig. 15 provides a graphical summary of the codes recorded in relation to influences on mode choice and their frequencies. This clearly shows the respondents' focus on the distorted perception of mobility costs on the part of users.

Remote work

Finally, the area of remote work (4.4.4) should be mentioned, which influences the choice of transport mode with two (also interrelated) central phenomena: the reduction of mobility and the shift of mobility.

The former contributes to the fact that public transport operators are faced with declining demand and the associated financial challenges. At the same time, private transport becomes more attractive due to the reduced use of the road network. The latter leads to the increase in leisure trips described at the beginning of the chapter, while work trips are eliminated. Fig. 16 provides a graphical summary of all codes recorded in relation to influences on remote work. The reduction in mobility through mobile work clearly predominated in the statements of those surveyed.

Code relations

The relations in the Mobility Behavior category reveal an unexpected circumstance: the most frequent connections were to statements

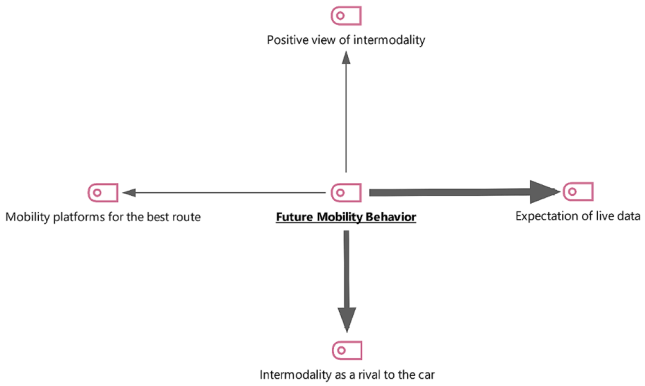

Fig. 14. Code subcode model on future mobility behavior.

Fig. 15. Code subcode model for the influences on mode choice.

Fig. 16. Code subcode model for remote work.

indicating an insufficient database or lack of data collection regarding users' mobility behavior. This suggests that providers are not yet able to personalize their offerings based on individual user behavior.

Further connections were found to inadequate infrastructure and data on traffic conditions. Overall, it can be observed that providers want to integrate more real-time information, but they are currently unable to do so.

The central connections within this category lie in users' perceptions of cars, public transportation, and mobility costs. This goes hand in hand with the aforementioned lack of data, as the respondents' assessments are based on their individual perceptions rather than a robust database.

Mobility planning and needs

This section deals with statements from the respondents about their mobility planning and needs assessment. These statements can be divided into two subcategories: the existing needs in mobility planning, their identification and the problems that arise in the process (4.5.1), and possible future scenarios in planning (4.5.2).

Needs, identification and problems

With regard to requirements, their recording and the problems that arise (4.5.1), the respondents most often talked about the role of collecting metrics that are particularly relevant to requirements gathering and planning in their respective areas.

In particular, respondents from the public transport, bike-sharing and car-sharing sectors provide detailed information on what information they use in each case and what problems they encounter in collecting and using this information.

Table 5 summarizes these points, broken down by the three sectors. It is striking that public transport and bike sharing, in particular, require related data, but also suffer from similar or complementary problems: for example, both systems are susceptible to sudden or localized peaks in demand. Similarly, both systems face the challenge of planning their vehicles in such a way as to avoid empty runs or transfers of vehicles. It is also interesting to note that, according to the respondents, both systems require financing models that are not solely based on payment for individual trips.

Table 5
Relevant data and problems in public transport, car sharing and bike sharing.

Sector	Relevant data	Problems
Public Transport	Passenger numbers, line utilization, demographics, needs and structureof individual neighborhoods, municipal finances, user needs	Rising acquisition and fuel costs, inappropriate financing models, missing data, missing forecasting models, peak periods, uneven demand distribution
Carsharing	Location-based demand and usage, station infrastructure context, willingness to pay	Operating costs in low demand areas, nationwide presence, high customer demand, competition
Bike sharing	Improving the mobility offer with conventional solutions	Station utilization, demographics, public transit access, number of potential users, user needs

Public transport currently solves this problem through municipal subsidies, while bike sharing providers rely on subscription models and partnerships with large institutions such as universities to achieve a constant and predictable flow of funds.

Accordingly, a standardization of data interfaces and service forms as well as a free exchange of data for providers would be desirable. In addition, these findings suggest a need to rethink the financing of public transport – one possibility would be subsidized subscription models that cover all modes of transport, such as the German government's "Deutschland-Ticket".

Car sharing also has similar characteristics in some areas. Here, too, demand varies greatly from place to place, so the context of each station must be taken into account. This leads to very high operating costs, especially in areas with low demand, as vehicles have to be provided for relatively few customers. In addition, Car-sharing providers face strong competition in high-demand areas. Fig. 17 provides a graphical summary of all codes recorded in relation to needs, their identification and related problems. The statements made by respondents highlight the shortcomings in particular with regard to the lack of data collection and analysis.

Future scenarios in planning

The future scenarios described by the providers (4.5.2) are in line with the previous findings: for example, the respondents most frequently assume that mobility will in future be seen even more as an aggregated service that is perceived independently of individual providers. This would lead to a convergence of products and distribution channels. This future scenario is complemented by two other ideas: the use of artificial intelligence to calculate optimal route chains and routes, and the emergence of smaller, local providers offering locally tailored solutions. The economic viability of such local offerings in such a scenario could be made possible by the fact that, as described above, they would hardly need their own sales channels or marketing strategies if their services were automatically included in an integrated offering. Such integration also helps to save resources.

Finally, there are potential problems with these scenarios. Providers see a dominance of US companies in the IT sector, which could make the development of integrated routing solutions more difficult. Specifically, they are concerned that these companies may tailor their routing proposals to their own commercial interests rather than calculating a sustainable solution. Fig. 18 provides a graphical summary of all codes recorded in relation to future scenarios in planning. The topic of mobility as a service stands out in particular here, which is in line with the booking platform desired by the respondents.

Code relations

Relations in this category largely revolve around the possibility of a central mobility platform or the concept of centralized, service-based mobility. This makes sense, as providers are expected to prioritize these phenomena in their future planning.

However, this category also includes relations to the social relevance of cars. While this may be surprising, it makes sense because this development will also have to be considered in future planning.

Finally, other relations target the business interests of mobility

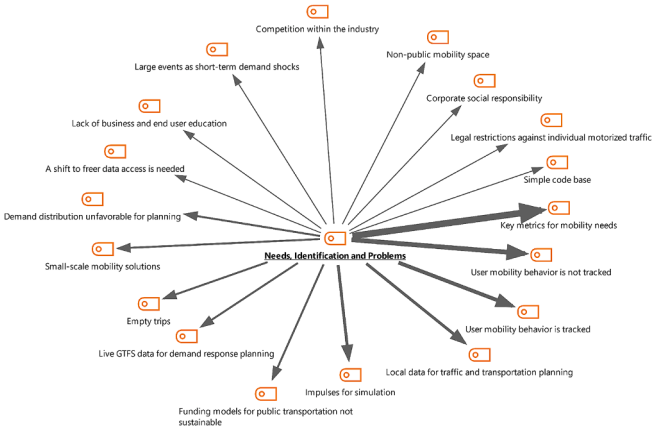

Fig. 17. Code subcode model on needs, identification and problems.

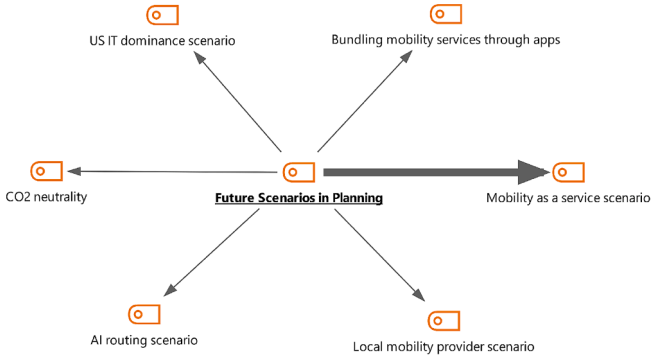

Fig. 18. Code subcode model on future scenarios in planning.

companies and the data required to achieve them.

Framework conditions

At the end of the evaluation of the main categories, this section explains the framework conditions that the respondents consider relevant for a change in mobility behavior. These framework conditions can be roughly divided into the subcategories of economic framework conditions (4.6.1), technical framework conditions (4.6.2), and government framework conditions (4.6.3).

The corresponding legal frameworks are discussed during the individual areas, since there are separate legal reference frameworks for the individual aspects of these three areas.

Economic framework conditions

Regarding the economic framework conditions (4.6.1), the respondents from the operational level emphasize in particular that the providers have to pursue their own business interests within the current transport system.

This has various effects on the system's ability to transform: on the one hand, the use of new technologies or the planning of a cycle time must always meet economic criteria in order to be implemented. On the other hand, these particular interests may hinder cooperation if, for example, a competitive disadvantage is suspected as a result of data sharing.

> "But there was also the fact that the public transportation companies were a bit of a stumbling block or just wanted to remain the central point of contact." (I.3)

As the quote above shows, the respondents from the regulatory area also mentioned in this context that local transport companies or regional transport associations are sometimes skeptical about the development of new solutions. On the one hand, this is due to the vested interests mentioned above, but on the other hand it is also due to a certain loss of control that could emerge if municipalities or planning offices were to determine the development of public transport beyond the current level. From the point of view of the municipal respondents, a structure in which there is a central coordinating authority that is independent of particular interests, coordinates transport planning and bundles the data of the individual transport providers, would make more sense. Fig. 19 provides a graphical summary of all codes recorded in relation to economic framework conditions. The statements made by those surveyed primarily focused on the business interests of mobility companies and the resulting presumed barriers to cooperation.

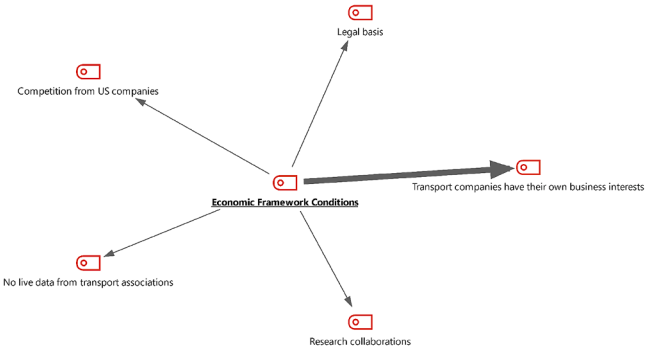

Fig. 19. Code subcode model on economic framework conditions.

Technical framework conditions

The aforementioned lack of centralization is also related to the technical framework conditions (4.6.2), as respondents often mention in this context that there is no central data exchange that would allow, for example, the booking of complete route chains.

Similarly, there is a lack of powerful algorithms that could be used for traffic and route planning in an intermodal system. The problems of insufficient, non-standardized data and insufficient algorithms are to some extent interrelated, since the data problem has so far made the development of such algorithms unattractive. However, from a technical point of view, these developments would be particularly necessary for on-demand transportation and the introduction of autonomous vehicles since these technologies require the above-mentioned points as technology enablers.

Respondents also mentioned a lack of infrastructure in terms of technical aspects beyond data exchange. For example, there is a lack of stations for setting up intermodal services, i.e., places where several modes of transport can be used and parked. There is also a lack of technical interfaces to connect existing infrastructure to new mobility services. Similarly, the lack of infrastructure in terms of cycle paths, especially outside large cities, is still a relevant issue. Fig. 20 provides a graphical summary of all codes recorded in relation to technical framework conditions. In terms of frequency, the lack of data was the main issue raised, followed by deficiencies in infrastructure.

Government framework conditions

Regarding the government framework conditions (4.6.3), the main issue raised is the legal basis for financing public transport due to insufficient budgets in the past. According to the respondents, there are several arguments (some of which have already been mentioned) against the management of public transport as a private enterprise. Thus, public transport has to ensure the mobility of all citizens in a non-discriminatory way in the sense of providing a public good. This means that connections that would not be profitable on their own must also be provided.

The interviewees see room for improvement in the fact that the lack of funds currently has to be provided mainly by the municipalities, which often have financial difficulties of their own. In order to increase the range and attractiveness of services, a central funding structure similar to the coordinating body described above would be required. This funding structure could also help to facilitate the administration of centralized tickets. In addition, the increasing use of mobile work is likely to result in even less profitable public transport routes in some cases, so that the need for subsidies is also likely to increase further. Fig. 21 provides a graphical summary of all codes recorded in relation to technical framework conditions. Here, the financial problems of public transport as well as its structure and public function were mentioned most frequently.

Code relations

The relations in this category are very similar to those in the previous category because they also primarily concern mobility platforms, the relevance of private cars, and insufficient data on mobility behavior and volume. This makes sense, as the technical and economic conditions in

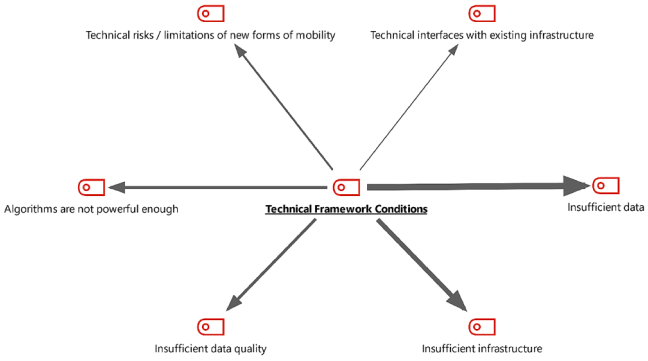

Fig. 20. Code subcode model for technical framework conditions.

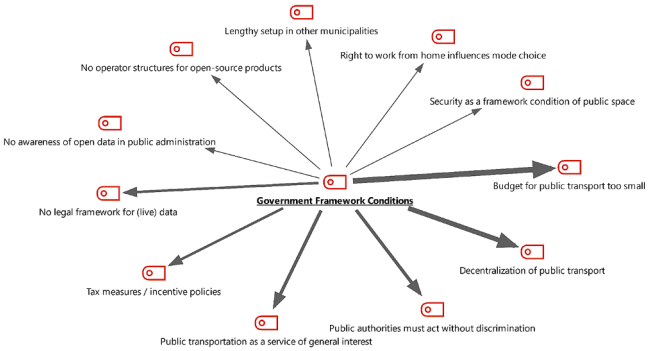

Fig. 21. Code subcode model on government framework conditions.

this category are central to these topics.

As previously mentioned, the interviewed providers would particularly like to see better data on individual mobility behavior. Interestingly, the fact that this data is not yet available stems from all three types of framework conditions discussed here. Particular economic interests and the legal framework for data protection have made it difficult to share such data thus far. Additionally, these circumstances have prevented the technical foundations from being established.

Distribution

Examining the respondents' statements individually according to their assigned governance levels reveals a distinct response pattern: As shown in Table 6, respondents at level GOV-1 (the political coordinating level) predominantly commented on the New Mobility, Mobility Behavior, and Mobility Planning and Needs categories. This is also the case for respondents at level GOV-3 (the operational level). However, here it can be seen that their comments are more evenly distributed across the categories and that they commented more on Current Mobility Services in particular. Respondents from GOV-2, the regulatory level, did not discuss this at all. Instead, these respondents made the highest proportion of comments on framework conditions.

While this distribution is not particularly surprising, it does indicate the priorities of members at these levels. It also shows that the current situation, especially the car's strong social position in the Ruhr region, is a priority for respondents involved in the operational implementation and marketing of mobility services. This could delay the transformation insofar as the other levels of governance are not (or no longer) focusing as strongly on these issues and have also assumed in their statements that social acceptance of innovative mobility solutions and the associated change in usage practices will be accepted or are already a given.

The implications for the transformation and development, as well as a critical discussion of the presented results, can be found in the next chapter.

Table 6
Frequency of statements by governance level overview (rounded column percentages).

Main Category	GOV-Level 1	GOV-Level 2	GOV-Level 3
Mobility and Corona	9,7 %	5,7 %	7,4 %
Current Mobility Services	4,0 %	0,0 %	12,1 %
New Mobility	24,0 %	25,7 %	28,5 %
Mobility Behavior	22,3 %	17,1 %	17,1 %
Mobility Planning and Needs	22,3 %	21,4 %	21,5 %
Framework Conditions	17,7 %	30,0 %	13,4 %

Discussion and conclusions

Discussion

It is particularly interesting that the observed decline in the use of public transport and car sharing during the pandemic was accompanied by a change in preferences and subjective utility calculations (Schneider, 2013; Weyer and Hoffmann, 2023). Hygiene and protection against infection suddenly became much more important than before, further strengthening the position of individual transport. This shows that a change in framework conditions (Geels, 2002) can lead to a re-evaluation of existing mobility alternatives by changing the subjective utility calculations and thus bring about a change in mobility behavior. Verplanken et al. (2008) also show that a change in contextual conditions is conducive to a change in mobility habits.

The presented studies on mobility behavior in Germany (Ecke et al., 2023; Follmer, 2025) reach similar conclusions about this development as the respondents do. Additionally, the general decline in mobility could lead to further changes in framework conditions. Commuting and business travel have been key forces that structure the everyday lives of employees (Vogl, 2009). As these activities become less common, new opportunities for transformation will emerge.

Also, not only the users but also the providers were affected by the decline in demand. New mobility companies, in particular, have suffered significant disadvantages as a result of the pandemic, as they had to adapt to a completely new situation shortly after entering the market.

The pandemic context is certainly an extreme scenario that no longer prevails, but changes in framework conditions also occur in other contexts. For instance, proficiency in usage skills is also a factor, and these skills are reinforced through the regular execution of specific routines. Conversely, the absence of these actions can lead to a weakening of these skills. This is particularly relevant with regard to the use of public transportation or digital services such as booking platforms, which are consequently less accepted. Durand et al. (2023) also address this point, but primarily focus on digital inequalities that could emerge due to changing demographics. Studer et al. (2025) investigate similar factors regarding acceptance in the context of autonomous ride pooling. However, it is reasonable to assume that this can be transferred to numerous services that offer digital access.

In the context of conventional means of transport, the main constraints mentioned by the respondents were the lack of flexibility in capacity and frequency of public transport and the high space requirements and low occupancy rates of private cars. From the providers' point of view, this lack of flexibility makes it difficult to respond optimally to the subjective utility calculations of their customers, since they would need vehicles that are as empty as possible and run as frequently as possible for the sake of comfort and reliability, which is not

economically feasible in the current situation, since the respondents see comfort as the most important factor in travelers' utility calculations.

According to the providers, this problem could be addressed by sharing services, on-demand solutions, and other digital services, provided that they are used together with conventional public transportation in a connected manner, rather than existing as a parallel offering. Interestingly, when discussing these improvements, especially the interviewees from GOV-1 and GOV-2 assumed that innovative services, such as car or bike sharing, were already established practices. This is surprising given that only a small proportion (0.7–0.9 %) of UA-Ruhr university members used sharing services for campus trips in 2020–2021 (Weyer, 2022), despite university members being considered a population with a high affinity for technology and innovation. Similarly, the respondents from GOV-3 stated that such improvements are not yet established in terms of infrastructure or common practices. According to Howaldt and Schwarz "social innovations differ from technical innovations in their immaterial, intangible structure. The new does not take place in the medium of technical artifacts, but at the level of social practices" (Howaldt and Schwarz, 2010). This underscores the fact that the actual prevalence and acceptance of certain services, particularly among those in higher levels of governance, is not being adequately assessed. This leads to a distorted view of the transportation system.

Another key result in the context of future mobility also primarily concerns acceptance: According to the respondents, the (perceived) ease of use of public transport could be significantly increased, especially for intermodal connections, if trip chains could be planned and booked as a whole within a unified system. Using the presented theories of acceptance, it can be assumed that such a change in perceived ease of use could initially lead to a change in attitude towards using such public transport services and thus ultimately to a change in their acceptance.

According to the respondents, such a unified booking platform would be necessary for sustainable change, as would a holistic transformation of the transport system beyond mere technical innovations to a fundamentally changed socio-technical system. Accordingly, the most likely future scenario, according to the respondents, is one in which mobility is offered by transport companies or even municipalities as an integrated service in which various services are bundled and interlinked to maximize usability and acceptance. This is also in line with other literature:

> "Subjective well-being when using autonomous vehicles is not only influenced by perceptions of the technology itself, but the specific design of a mobility service using this technology also has a measurable influence on the expected well-being of respondents. In addition, there are clear differences according to gender, age, and typical mode of transportation use." (Fleischer et al., 2022)

Nevertheless, this consideration does not end with the TAM since it only covers acceptance. Travelers' attitudes, norms, and habits also play a central role in whether a particular mobility service is chosen and in determining the conditions for choosing a certain mode of transportation. Currently, the private car is a "component of modern societies and lifestyles" (Manderscheid, 2022) and has a privileged image in society according to the interviewees. As Weyer (2022) also finds, many users consider the private car superior to public transportation and bicycles in terms of speed, comfort, safety, and reliability. This, together with a general resentment and aversion to public transport in the current situation, contributes to a preference for the car. This preference is further supported by the fact that, contrary to reality, the cost of MIT is often perceived to be lower than that of public transport.

This is also found by other studies as the subjectively perceived financial cost is paradoxically often estimated to be lower than the actual cost of traveling by car (Manderscheid, 2022). According to Weert Canzler (2009), "the driver's own work is [also] not calculated". This means that another advantage of public transport, the possibility to perform other activities during the trip, is not sufficiently perceived. From a sociological standpoint, the origins of these perceptions lie not least in "cultural anchors in social knowledge and notions of normality" (Manderscheid, 2022), through which certain values have been ascribed to the car over a long period of time. However, these values obviously do not necessarily correspond to actual circumstances.

It is also noteworthy that other empirical studies on mobility cultures conclude that there is a contrary social norm that marks the use of public transport as socially desirable (Bamberg et al., 2020). This discrepancy vividly illustrates the dilemma between situational needs for comfort and environmental friendliness, which may influence the choice of transport mode. In the context of mobility behavior, this means that the current relevance of the private car would have to be significantly weakened by serious competition from (new) intermodal solutions on GOV-3 as well as regulations from GOV-1 for such a change to be possible.

Regarding the framework conditions, it should be noted that in the current situation, transport companies often pursue their own business interests, which has so far been an obstacle to the integration of services according to the respondents. This is because the respective companies fear competitive disadvantages if they share their data and have therefore so far pursued their own methods of recording the necessary parameters.

Another obstacle resulting from this is the currently still insufficient data base and quality, as well as the (technical) infrastructure required for an integration of shared data and services among different companies. According to the respondents, a necessary legal framework for this integration is also not yet sufficiently in place. In addition, in the current legal framework for public transport, there are separate authorities for road and rail, which, in the case of roads, are also highly fragmented at the municipal level (Bundesministerium der Justiz, 1993; mobil.nrw, 2020). Remarkably, although the interviews took place some time ago, there is still no unified booking platform. A unified data platform for the Ruhr region (and the entire state of North Rhine-Westphalia) was just introduced in May 2025 by the state agency Mobidrom[6] and is still new. This means that the joint use of data remains a future goal and is not yet an established practice. Mubiru (2025) comes to similar conclusions regarding the fact that current structures prevent development in various cases.

In general, respondents believe that a transformation of the mobility system requires broad government support: in addition to the legal framework, a larger budget is needed for the expansion of public transport. Specifically, this means that economic sustainability of public transport should not be established within the provision of the mobility service itself but should take into account that accessible and efficient public transport has a positive impact on the economic performance of its catchment area as Rauh and Bleckmann (2004) already stated.

Accordingly, public transport services are provided in the general economic interest in the view of the Association of Transport Companies (Verband der Verkehrsunternehmen, 2023). As the respondents repeatedly mentioned, they therefore constitute a public resource for providing services of general interest. Given this, it is questionable to what extent public transportation should be guided by economic considerations and interests. From this perspective, public transportation should be regarded as a means to an end rather than as a separate business sector. This aligns with the findings of Minnich et al. (2024), who use a behavioral economics approach to examine on-demand transportation and incorporate it into a public goods model. This allows them to more accurately reflect users' decisions regarding their preferred modes of transportation. Applied to all public transport in the Ruhr region in the future, this could mean that financial considerations would be less of an obstacle when choosing a mode of transport.

Future studies should therefore focus specifically on tracking the

[6] The data platform is available to municipalities, public institutions, and mobility providers at "https://www.mobidrom.nrw/produkte/mobidrom-datenplattform".

developments desired by the respondents. In the context of the recently introduced data platform for North Rhine-Westphalia, it should be determined whether this will have the effect of simplifying communication and data transmission between different stakeholders. It should also be determined whether this improved data access across the various governance levels will result in a more accurate picture of the situation than is currently available.

In addition, the question of how providers will promote acceptance of their services in the future and what impact this will have on established usage practices is of particular interest. In addition to the question of whether the long-awaited booking platform will be created, the focus here is also on whether and how communication between the governance levels and between providers and customers will change.

Finally, it will need to be clarified how the Ruhr region will actually progress in its transformation from an industrial location to an innovation hub, as Mubiru (2025) or Melkonyan et al. (2020) expect. This would, in turn, bring about significant changes in mobility requirements and, consequently, in the landscape.

Limitations

The statements of the interviewees cannot be generalized, but only represent the perspective of selected providers in the context of the Ruhr Region. For further research, it would therefore be advisable to try to validate these points among users, since their perspective can only be obtained second-hand here. Similarly, the conclusions drawn are only valid in the context of the distinct theoretical perspective on mode choice adopted here. It is therefore conceivable that other factors also influence mode choice and that there are more starting points for changing behavior than are discussed in this article.

Also, the respondents certainly only partially represent the views of entire organizations, so their statements cannot be used exhaustively to explain organizational actions, although this is not the purpose of this article.

Due to its age, it should be noted that the data used in this study may not reflect all current views of the respective providers. Nevertheless, the points raised here remain largely valid and relevant in the context of the Ruhr region's transport system. The specific circumstances surrounding the pandemic are also no longer present in today's context, and this is something that must be taken into account. However, these circumstances were fundamental to certain developments and continue to have an impact today. As previous studies (Sottile et al., 2024; Mohammadi-Mavi et al., 2025) have shown, the willingness to use shared transportation has significantly declined, while the use of individual transportation has continued to grow.

Furthermore, considering the specifics of the local transport system means these results cannot be easily applied to Germany as a whole. However, such an approach would not be recommended from the perspective of this article, since the local context, including existing governance structures, should always be considered when examining such systems.

Due to changing economic, environmental and social contexts, it is also conceivable that such changes (for example, rising fuel prices, increased social inequality, or changing cityscapes) will already lead to a reconfiguration of situational needs and preferences. This, in turn, could lead to different processes of transport mode choice than today and invoke new requirements for providers in the Ruhr Region.

Conclusions and recommendations

Overall, it can be concluded that the respondents in this study present a fairly homogeneous picture of the mobility system in the Ruhr region in many areas. Nevertheless, they place different emphases, especially with regard to the assumption that developments in acceptance and usage practices have already been completed.

However, based on current knowledge, this is not the case. A key finding of this study is therefore that mobility providers should take different measures to properly evaluate and then increase the uptake and acceptance of new public services depending on the level of governance to which they belong. When considering mobility in the future, provider's focus should not only be on new services and new technology as it was often the case in the interviews, it should also be on resulting social innovations and changes in usage practices.

For mobility providers at the operational level GOV-3, this means they should actively develop and integrate new services and promote their acceptance. Additionally, periods of change should be leveraged to underscore the benefits of these services, such as ride-sharing, compared to traditional cars, to mitigate the latter's position. This could be done by comparing the environmental consequences of individual alternatives or by highlighting financial or time-related advantages. This is a particularly key issue in the Ruhr region, where the infrastructure for new public services is available, yet satisfaction with existing car alternatives has been low so far. For providers involved at the coordinating and regulatory levels GOV-1 and GOV-2, however, this means that they should use legislation to change the previously very privileged position of private cars. On the one hand, this could be achieved by reducing parking spaces or restricting access to city centers, although such measures might sometimes be beyond the control of the respondents. On the other hand, such a disincentive could also be provided, for example, by the fact that route suggestions that include MIT are displayed as a lower priority in the corresponding app of the transport company.

Members of higher governance levels also have better opportunities than GOV-3 members to create unified data and booking platforms and infrastructures that are another key desideratum of this study. Although a data platform for the Ruhr region was recently launched, a unified booking platform remains elusive. However, both are considered key components of a new public mobility system in the Ruhr region by the providers surveyed. It remains to be seen whether the changes towards such a booking platform will occur as expected and have the expected effects.

It is interesting to note that this socio-technical configuration of Governance Levels in the Ruhr Region's transportation system is primarily of political (and not practical) origin, as municipalities, as public transport authorities at the GOV-2 level, often have the operations managed by (consequently also municipal) transport companies at the GOV-3 level. The need for coordination is then regulated by transport associations (also GOV-3). From a point of view of efficiency, an overall more centralized governance structure would be preferable according to the interviewees. However, such a development is not to be expected.

Another key point is the need to change the financing structure of public transportation. According to the respondents, public transportation should not be viewed as a separate business sector with an expected profit margin. Rather, it should be seen as public infrastructure that empowers people and the local economy. The resulting subsidies would give public transportation providers more freedom to design and plan their services, enabling them to better meet demand for comfort and flexibility.

Fig. 22 summarizes the key findings and relates them to the presented theoretical foundations. This highlights the interrelationships between the individual points and clarifies why these seemingly unrelated topics are ultimately part of an overall socio-technical system. To achieve the holistic transformation of the transport system in the Ruhr

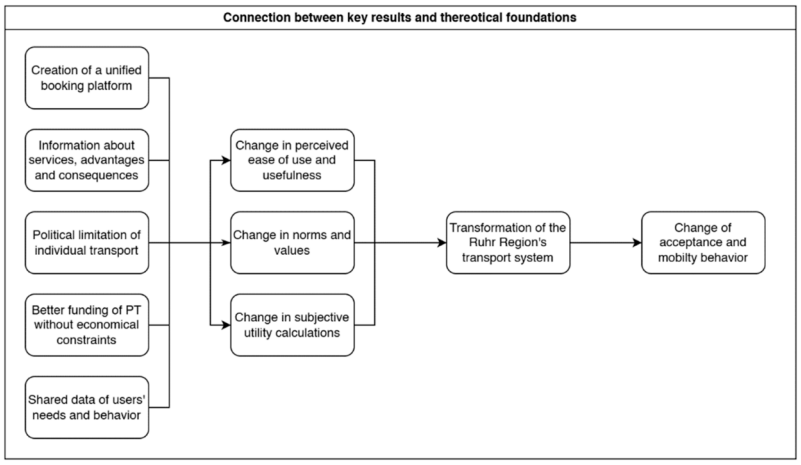

Fig. 22. Connection of key results and theoretical foundations.

region desired by the respondents, they should always be considered in their mutual context.

Credit authorship contribution statement

Kay Kohaupt-Cepera: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Interview guide

Welcome / "Opener":

1. Introduction of the participants, their companies and the project
2. What are possible future scenarios for transport in the Ruhr area?

Mobility and Corona (mobility under normal conditions vs. in crisis mode):

1. What was the situation before Corona?
2. What has changed?

Sustainability / Modal Split (development of sustainable offers and mobility behavior):

1. What measures for sustainable mobility have been taken?
2. What changes are we facing in terms of transportation use?
3. Are sustainable services being (better) accepted?

New technologies (attitudes towards new technologies and mobility services):

1. What are the attitudes of the respective experts towards new services such as car-sharing, ride-sharing, etc.?
2. What is the attitude of the respective experts towards new drive technologies such as hybrid, electric or hydrogen?

Mobility needs (supply- or demand-oriented mobility planning, future scenarios, user preferences):

1. How does the company assess needs and how are they used in planning?
2. How could our needs assessment and our project benefit the company?
3. What scenarios are suitable for testing in the simulator?
4. What changes do the interview partners want to see in the region/organization?

Exemplary application of the multi-level governance model to the transportation system

Fig. 23 shows the application of this theory to the example of public transportation: At the top level (GOV-1), the future design of public transport is negotiated between politicians (e.g. in the form of the German Federal Ministry for Digital and Transport), associations such as the Association of Transport Companies, and other stakeholders, after which measures are designed to help achieve this design (Konrad et al., 2020). An example of this would be the goal of reducing the financial burden on users, with the "9-euro ticket" serving as a corresponding measure in this example. Consequently, the top-level passes on objectives and measures to the lower level of regulation of functional subsystems (GOV-2) in a coordinating manner.

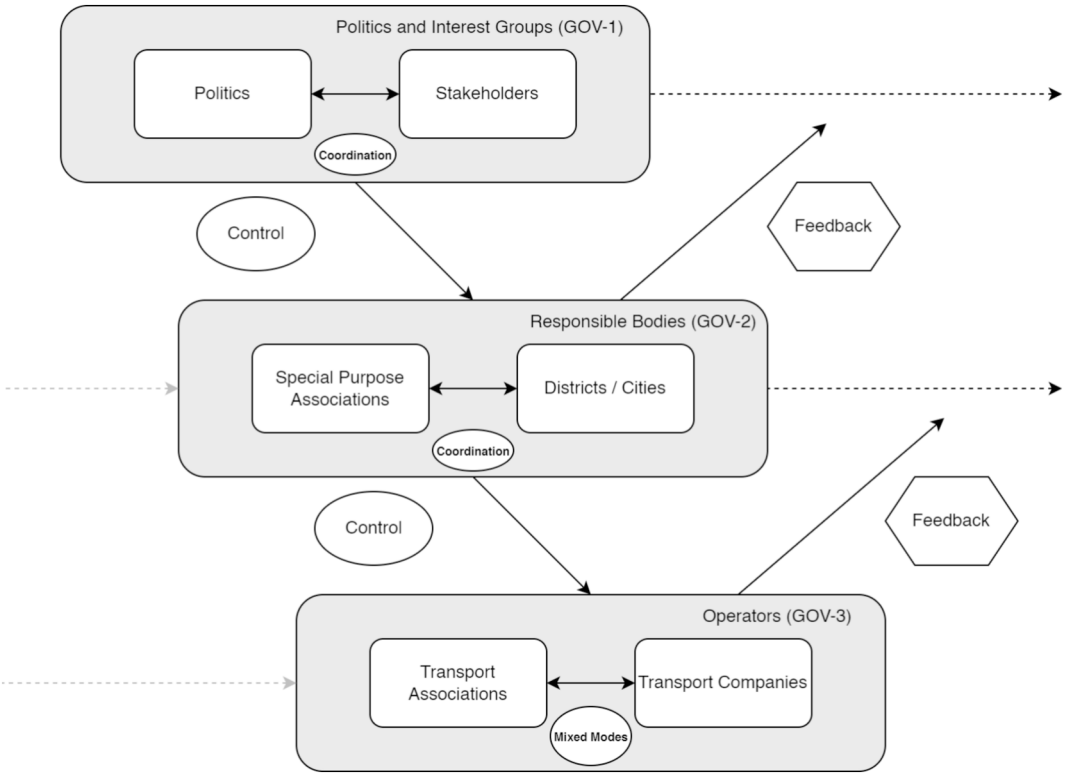


Fig. 23. Exemplary application of the multi-level governance model to the transportation system (Konrad et al., 2020).

At this second level, there are Responsible Bodies such as public transport authorities. According to the Regionalization Act, these can be, for example, special-purpose associations or state-owned companies in local rail passenger transport (SPNV) and district or city administrations in local road passenger transport (ÖSPV) (mobil.nrw, 2020). These bodies have the task of "translating political goals and measures into practicable standards and rules" (Konrad et al., 2020). Feedback to the higher level can take place via the numerous interfaces between authorities and politicians, e.g., in working groups. In relation to the example of the 9-euro ticket, this could mean the planning of a sales infrastructure or the formulation of access rules.

These plans are then implemented at the operational management level (GOV-3) by the public transport operators in the form of concrete measures in such a way that the operation of the respective subsystems is possible. The actors at this level are often supported by the special purpose associations at the level above and are thus closely linked to them, which enables a continuous feedback process. They are also the central interface between users and the public transport system as a whole. In the case of the 9-euro ticket, this would mean the organization and implementation of sales as well as the transport of passengers with such a ticket. From a governance point of view, this measure not only fulfills a relief function, but can also be seen as an incentive-based, soft control measure that acts from the public transport subsystem on the mobility behavior in the entire transport system.

Frequency tables for subcodes

Mobility and Corona

Table 7
Subcodes of the main category Mobility and Corona.

Code No.	Subcode	Number of Coded Passages
4.1.1.1	Decline in public transport and sharing use	11
4.1.1.2	Return to pre-pandemic mobility behavior	5
4.1.1.3	Importance of hygiene on public transportation	3
4.1.1.4	Individual alternatives to motorized transportation	3
4.1.1.5	Working from home reduces mobility requirements	2
4.1.1.6	Decline in tourist travel	1
4.1.2.1	Competitive disadvantages for new businesses	6
4.1.2.2	Positive effects/no disadvantages due to Covid	3
4.1.2.3	Delay in practical research on mobility	3
4.1.2.4	Corona insecurity as a barrier to mobility development	2
4.1.2.5	Adjustment of public transport fares	1
4.1.2.6	Decline in automotive industry even before Corona	1
4.1.2.7	More cooperation between mobility providers	1
4.1.2.7	Positive impact on motorized individual transport	1

Current mobility services

Table 8
Subcodes of the main category Current Mobility Services.

No.	Subcode	Number of Coded Passages
4.2.1.1	Limitations of conventional means of transportation	8
4.2.1.2	Decentralized structure of public transport	4
4.2.1.3	Improving the mobility offer with conventional solutions	2
4.2.1.4	Financial limitations of public transport	2
4.2.1.5	Restriction of other road users by MIT	1
4.2.2.1	Sharing solutions	7
4.2.2.2	Current approaches to intermodal mobility	6
4.2.2.3	Supplementing the conventional mobility offering	5
4.2.2.4	Pilot projects with municipalities	5
4.2.2.5	On demand principle	3

New mobility

Table 9
Subcategories of the main category New Mobility.

No.	Subcode	Number of Coded Passages
4.3.1.1	Improving innovative mobility services	15
4.3.1.2	Integration of new mobility services into existing ones	13
4.3.1.3	Limitations of non-MIT solutions	13
4.3.1.4	Alternative drives	5
4.3.1.5	Increased importance of cycling	4
4.3.1.6	New pricing models for mobility providers	4
4.3.1.7	Innovative mobility combined with housing	4
4.3.1.8	Non-profit, open source	3
4.3.1.9	Mobility as municipal service	3
4.3.1.10	Users value intermodal routing	3
4.3.1.11	Mobility niches with innovative means of transport	2
4.3.1.12	Requirements for innovation projects	2
4.3.1.13	Rather low mobility innovation	1
4.3.2.1	Intermodal mobility platform for sustainable mobility	16
4.3.2.2	User-centricity of the mobility platform	6
4.3.2.3	Optimization with regard to ecological sustainability	5
4.3.2.4	MIT is explicitly disadvantaged	4
4.3.3.1	Holistic transformation of the transportation system	11
4.3.3.2	Social acceptance	9
4.3.3.3	Long-term promotion of MIT alternatives	5
4.3.3.4	Transformation to regional mobility providers	5
4.3.3.5	Thinking mobility across Germany or Europe	4
4.3.3.6	Demand-driven mobility solutions	3

(*continued on next page*)

Table 9 (*continued*)

No.	Subcode	Number of Coded Passages
4.3.3.7	Fully sustainable mobility is virtually impossible	2
4.3.3.8	Change towards centralization of transport associations	2
4.3.3.9	Popularity of MIT does not change	1

Mobility behavior

Table 10
Subcategories of the main category Mobility Behavior.

No.	Subcode	Number of Coded Passages
4.4.1.1	Relevance of the car	21
4.4.1.2	Comfort as the most important factor	9
4.4.1.3	MIT more popular than public transport	8
4.4.1.4	Aversions against public transport	7
4.4.1.5	Special target group of innovative mobility	7
4.4.1.6	General resentments	7
4.4.1.7	Transfers as a barrier to transport use	4
4.4.1.8	Ecological sustainability unimportant for customers	4
4.4.1.9	Individual transport attractive for first and last mile	4
4.4.1.10	Popularity of the bicycle	3
4.4.1.11	Mobility in non-public spaces	2
4.4.1.12	Carpooling services are currently not used	2
4.4.1.13	Differences between urban and rural areas	1
4.4.2.1	Expectation of live data	4
4.4.2.3	Intermodality as a rival to the car	3
4.4.2.3	Positive view of intermodality	1
4.4.2.4	Mobility platforms for the best route	1
4.4.3.1	Perception of mobility costs	8
4.4.3.2	Low visibility of public transport for MIT users	1
4.4.4.1	Reduced mobility through remote work	3
4.4.4.2	Shift in mobility through remote work	2

Mobility planning and needs

Table 11
Subcategories of the main category Mobility Planning and Needs.

No.	Subcode	Number of Coded Passages
4.5.1.1	Key metrics for mobility needs	15
4.5.1.2	User mobility behavior is not tracked	10
4.5.1.3	User mobility behavior is tracked	8
4.5.1.4	Local data for traffic and transportation planning	7
4.5.1.5	Impulses for simulation	6
4.5.1.6	Live GTFS data for demand response planning	5
4.5.1.7	Funding models for public transportation not sustainable	5
4.5.1.8	Demand distribution unfavorable for planning	4
4.5.1.9	Empty trips	4
4.5.1.10	Small-scale mobility solutions	4
4.5.1.11	A shift to freer data access is needed	3
4.5.1.12	Simple code base	1
4.5.1.13	Lack of business and end user education	1
4.5.1.14	Large events as short-term demand shocks	1
4.5.1.15	Competition within the industry	1
4.5.1.16	Non-public mobility space	1
4.5.1.17	Corporate social responsibility	1
4.5.1.18	Legal restrictions against individual motorized traffic	1
4.5.2.1	Mobility as a service scenario	26
4.5.2.2	Local mobility provider scenario	5
4.5.2.3	AI routing scenario	4
4.5.2.4	CO2 neutrality	3
4.5.2.5	Bundling mobility services through apps	1
4.5.2.6	US IT dominance scenario	1

Framework conditions

Table 12
Subcategories of the main category Framework Conditions.

No.	Subcode	Number of Coded Passages
4.6.1.1	Transport companies have their own business interests	14
4.6.1.2	Research collaborations	3
4.6.1.3	Legal basis	1
4.6.1.4	No live data from transport associations	1
4.6.1.5	Competition from US companies	1
4.6.2.1	Insufficient data	10
4.6.2.2	Insufficient infrastructure	8
4.6.2.3	Algorithms are not powerful enough	6
4.6.2.4	Insufficient data quality	6
4.6.2.5	Technical risks / limitations of new forms of mobility	5
4.6.2.6	Technical interfaces with existing infrastructure	3
4.6.3.1	Budget for public transport too small	6
4.6.3.2	Decentralization of public transport	5
4.6.3.3	Public transportation as a service of general interest	4
4.6.3.4	Public authorities must act without discrimination	4
4.6.3.5	Tax measures / incentive policies	3
4.6.3.6	No legal framework for (live) data	3
4.6.3.7	Right to work from home influences mode choice	2
4.6.3.8	No awareness of open data in public administration	2
4.6.3.9	No operator structures for open-source products	2
4.6.3.10	Lengthy setup in other municipalities	2
4.6.3.11	Security as a framework condition of public space	1

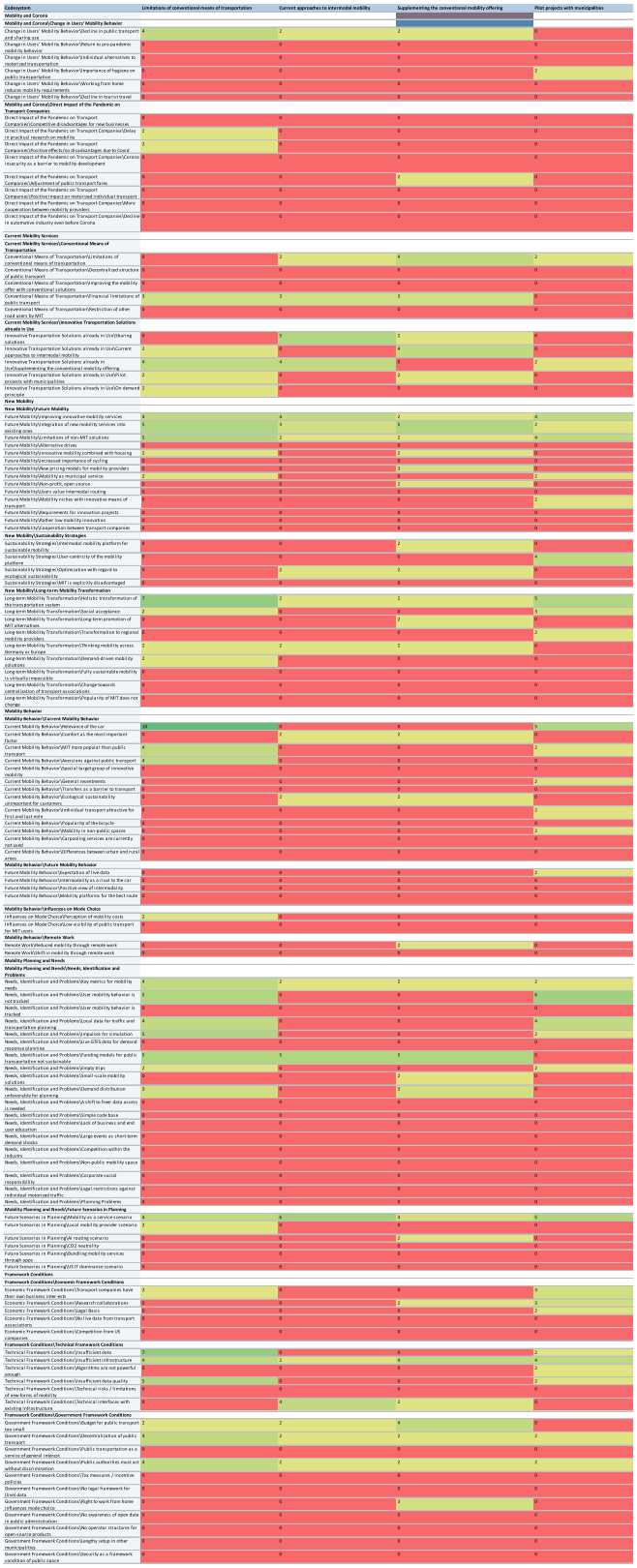
Code relation tables

Mobility and Corona

Codesystem	Decline in public transport and sharing use	Return to pre-pandemic mobility behavior	Competitive disadvantages for new businesses
Mobility and Corona			
Mobility and Corona\Change in Users' Mobility Behavior			
Change in Users' Mobility Behavior\Decline in public transport and sharing use	0	5	5
Change in Users' Mobility Behavior\Return to pre-pandemic mobility behavior	5	0	0
Change in Users' Mobility Behavior\Individual alternatives to motorized transportation	5	5	2
Change in Users' Mobility Behavior\Importance of hygiene on public transportation	2	0	2
Change in Users' Mobility Behavior\Working from home reduces mobility requirements	4	0	0
Change in Users' Mobility Behavior\Decline in tourist travel	2	5	0
Mobility and Corona\Direct Impact of the Pandemic on Transport Companies			
Direct Impact of the Pandemic on Transport Companies\Competitive disadvantages for new businesses	5	0	0
Direct Impact of the Pandemic on Transport Companies\Delay in practical research on mobility	2	0	5
Direct Impact of the Pandemic on Transport Companies\Positive effects/no disadvantages due to Covid	5	0	4
Direct Impact of the Pandemic on Transport Companies\Corona insecurity as a barrier to mobility development	2	0	0
Direct Impact of the Pandemic on Transport Companies\Adjustment of public transport fares	0	0	0
Direct Impact of the Pandemic on Transport Companies\Positive impact on motorized individual transport	0	0	0
Direct Impact of the Pandemic on Transport Companies\More cooperation between mobility providers	0	2	0
Direct Impact of the Pandemic on Transport Companies\Decline in automotive industry even before Corona	2	3	0
Current Mobility Services			
Current Mobility Services\Conventional Means of Transportation			
Conventional Means of Transportation\Limitations of conventional means of transportation	4	0	0
Conventional Means of Transportation\Decentralized structure of public transport	0	0	0
Conventional Means of Transportation\Improving the mobility offer with conventional solutions	0	0	0
Conventional Means of Transportation\Financial limitations of public transport	3	0	0
Conventional Means of Transportation\Restriction of other road users by MIT	0	0	0
Current Mobility Services\Innovative Transportation Solutions already in Use			
Innovative Transportation Solutions already in Use\Sharing solutions	0	0	0
Innovative Transportation Solutions already in Use\Current approaches to intermodal mobility	2	0	0
Innovative Transportation Solutions already in Use\Supplementing the conventional mobility offering	2	0	0
Innovative Transportation Solutions already in Use\Pilot projects with municipalities	0	0	0
Innovative Transportation Solutions already in Use\On demand principle	0	0	0
New Mobility			
New Mobility\Future Mobility			
Future Mobility\Improving innovative mobility services	0	2	0
Future Mobility\Integration of new mobility services into existing ones	0	2	2
Future Mobility\Limitations of non-MIT solutions	5	0	2
Future Mobility\Alternative drives	0	0	0
Future Mobility\Innovative mobility combined with housing	0	0	0
Future Mobility\Increased importance of cycling	2	5	0
Future Mobility\New pricing models for mobility providers	0	0	0
Future Mobility\Mobility as a municipal service	0	0	0
Future Mobility\Non-profit, open source	0	0	0
Future Mobility\Users value intermodal routing	0	0	2
Future Mobility\Mobility niches with innovative means of transport	0	0	0
Future Mobility\Requirements for innovation projects	0	0	0
Future Mobility\Rather low mobility innovation	0	0	0
Future Mobility\Cooperation between transport companies	0	0	0
New Mobility\Sustainability Strategies			
Sustainability Strategies\Intermodal mobility platform for sustainable mobility	0	0	0
Sustainability Strategies\User-centricity of the mobility platform	0	0	0
Sustainability Strategies\Optimization with regard to ecological sustainability	0	4	0
Sustainability Strategies\MIT is explicitly disadvantaged	0	0	0
New Mobility\Long-term Mobility Transformation			
Long-term Mobility Transformation\Holistic transformation of the transportation system	2	0	0
Long-term Mobility Transformation\Social acceptance	0	0	0
Long-term Mobility Transformation\Long-term promotion of MIT alternatives	0	0	0
Long-term Mobility Transformation\Transformation to regional mobility providers	0	0	0
Long-term Mobility Transformation\Thinking mobility across Germany or Europe	2	2	0
Long-term Mobility Transformation\Demand-driven mobility solutions	0	0	0
Long-term Mobility Transformation\Fully sustainable mobility is virtually impossible	0	0	0
Long-term Mobility Transformation\Change towards construction of transport associations	0	0	0
Long-term Mobility Transformation\Popularity of MIT does not change	2	3	0
Mobility Behavior			
Mobility Behavior\Current Mobility Behavior			
Current Mobility Behavior\Relevance of the car	2	0	0
Current Mobility Behavior\Comfort as the most important factor	0	0	0
Current Mobility Behavior\MIT more popular than public transport	2	3	0
Current Mobility Behavior\Aversions against public transport	4	0	0
Current Mobility Behavior\Special target group of innovative mobility	0	0	0
Current Mobility Behavior\General resentments	0	0	0
Current Mobility Behavior\Transfers as a barrier to transport	0	0	0
Current Mobility Behavior\Ecological sustainability unimportant for customers	0	0	0
Current Mobility Behavior\Individual transport attractive for first and last mile	0	0	0
Current Mobility Behavior\Popularity of the bicycle	0	0	0
Current Mobility Behavior\Mobility in non-public spaces	0	0	0
Current Mobility Behavior\Carpooling services are currently not used	2	0	2
Current Mobility Behavior\Differences between urban and rural areas	0	0	0
Mobility Behavior\Future Mobility Behavior			
Future Mobility Behavior\Expectation of live data	0	0	0
Future Mobility Behavior\Intermodality as a rival to the car	0	0	0
Future Mobility Behavior\Positive view of intermodality	0	0	0
Future Mobility Behavior\Mobility platforms for the best route	0	0	0
Mobility Behavior\Influences on Mode Choice			
Influences on Mode Choice\Perception of mobility costs	0	2	0
Influences on Mode Choice\Low visibility of public transport for MIT users	0	0	0
Mobility Behavior\Remote Work			
Remote Work\Reduced mobility through remote work	4	3	0
Remote Work\Shift in mobility through remote work	2	5	0
Mobility Planning and Needs			
Mobility Planning and Needs\Needs, Identification and Problems			
Needs, Identification and Problems\Key metrics for mobility needs	2	0	2
Needs, Identification and Problems\User mobility behavior is not tracked	0	0	5
Needs, Identification and Problems\User mobility behavior is tracked	0	0	0
Needs, Identification and Problems\Local data for traffic and transportation planning	0	2	0
Needs, Identification and Problems\Impulses for simulation	2	0	0
Needs, Identification and Problems\Live GTFS data for demand response planning	0	0	0
Needs, Identification and Problems\Funding models for public transportation not sustainable	5	0	0
Needs, Identification and Problems\Empty trips	2	0	0
Needs, Identification and Problems\Small-scale mobility solutions	0	0	0
Needs, Identification and Problems\Demand distribution unfavorable for planning	0	0	0
Needs, Identification and Problems\A shift to freer data access is needed	0	0	0
Needs, Identification and Problems\Simple code base	0	0	0
Needs, Identification and Problems\Lack of business and end user education	0	0	0
Needs, Identification and Problems\Large events as short-term demand shocks	2	0	0
Needs, Identification and Problems\Competition within the industry	0	0	0
Needs, Identification and Problems\Non-public mobility space	0	0	0
Needs, Identification and Problems\Corporate social responsibility	0	0	0
Needs, Identification and Problems\Legal restrictions against individual motorized traffic	0	0	0
Needs, Identification and Problems\Planning Problems	0	0	0
Mobility Planning and Needs\Future Scenarios in Planning			
Future Scenarios in Planning\Mobility as a service scenario	0	0	0
Future Scenarios in Planning\Local mobility provider scenario	0	0	0
Future Scenarios in Planning\AI routing scenario	0	0	0
Future Scenarios in Planning\CO2 neutrality	0	0	0
Future Scenarios in Planning\Bundling mobility services through apps	0	0	0
Future Scenarios in Planning\DB IT dominance scenario	0	0	0
Framework Conditions			
Framework Conditions\Economic Framework Conditions			
Economic Framework Conditions\Transport companies have their own business interests	2	0	0
Economic Framework Conditions\Research collaborations	0	0	0
Economic Framework Conditions\Legal Risks	0	0	0
Economic Framework Conditions\We live data from transport associations	0	0	0
Economic Framework Conditions\Competition from US companies	0	0	0
Framework Conditions\Technical Framework Conditions			
Technical Framework Conditions\Insufficient data	0	0	3
Technical Framework Conditions\Insufficient infrastructure	2	0	0
Technical Framework Conditions\Algorithms are not powerful enough	0	0	0
Technical Framework Conditions\Insufficient data quality	0	0	3
Technical Framework Conditions\Technical risks / limitations of new forms of mobility	0	0	0
Technical Framework Conditions\Technical interfaces with existing infrastructure	0	0	0
Framework Conditions\Government Framework Conditions			
Government Framework Conditions\Budget for public transport too small	5	0	2
Government Framework Conditions\Decentralization of public transport	2	0	0
Government Framework Conditions\Public transportation as a service of general interest	0	0	0
Government Framework Conditions\Public authorities must act without discrimination	2	0	0
Government Framework Conditions\Tax measures / incentive policies	0	3	0
Government Framework Conditions\No legal framework for (live) data	0	0	0
Government Framework Conditions\Right to work from home influences mode choice	0	0	0
Government Framework Conditions\No awareness of open data in public administration	0	0	0
Government Framework Conditions\No operator structures for open source products	0	0	0
Government Framework Conditions\Lengthy setup in other municipalities	0	0	0
Government Framework Conditions\Security as a framework condition of public space	0	0	0

Fig. 24. Code Relation Table for Mobility and Corona.

Current mobility services



Codesystem	Limitations of conventional means of transportation	Current approaches to intermodal mobility	Supplementing the conventional mobility offering	Pilot projects with municipalities
Mobility and Corona				
Mobility and Corona\Change in Users' Mobility Behavior				
Change in Users' Mobil ity Behavior\Decline in public transport and sharing use	4	2	2	0
Change in Users' Mobil ity Behavior\Return to pre-pandemic mobility behavior	0	0	0	0
Change in Users' Mobil ity Behavior\Individual alternatives to motorized transportation	0	0	0	0
Change in Users' Mobil ity Behavior\Importance of hygiene on public transportation	0	0	0	2
Change in Users' Mobil ity Behavior\Working from home reduces mobility requirements	0	0	0	0
Change in Users' Mobil ity Behavior\Decline in tourist travel	0	0	0	0
Mobility and Corona\Direct Impact of the Pandemic on Transport Companies				
Direct Impact of the Pandemic on Transport Companies\Competitive disadvantages for new bus routes	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Delay in practical research on mobility	2	0	0	0
Direct Impact of the Pandemic on Transport Companies\Positive effects/no disadvantages due to Covid	2	0	0	0
Direct Impact of the Pandemic on Transport Companies\Corona insecurity as a barrier to mobility development	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Abstinence of public transport firms	0	0	2	0
Direct Impact of the Pandemic on Transport Companies\Positive impact on motorized individual transport	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Worsening of the financial situation	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Decline in automotive industry even before Corona	0	0	0	0
Current Mobility Services				
Current Mobility Services\Conventional Means of Transportation				
Conventional Means of Transportation\Limitations of conventional means of transportation	4	2	4	2
Conventional Means of Transportation\Decentralized structure of public transport	0	0	0	0
Conventional Means of Transportation\Improving the mobility offer with conventional solutions	0	0	0	0
Conventional Means of Transportation\Financial limitations of public transport	3	3	3	0
Conventional Means of Transportation\Restriction of other road users by MIT	0	0	0	0
Current Mobility Services\Innovative Transportation Solutions already in Use				
Innovative Transportation Solutions already in Use\Sharing solutions	5	5	2	0
Innovative Transportation Solutions already in Use\Current approaches to intermodal mobility	2	0	4	0
Innovative Transportation Solutions already in Use\Supplementing the conventional mobility offering	4	4	0	2
Innovative Transportation Solutions already in Use\Pilot projects with municipalities	2	0	2	0
Innovative Transportation Solutions already in Use\On demand services	2	0	0	0
New Mobility				
New Mobility\Future Mobility				
Future Mobility\Improving innovative mobility services	4	4	2	4
Future Mobility\Integration of new mobility services into existing ones	5	3	5	2
Future Mobility\Limitations of non-MIT solutions	5	2	2	4
Future Mobility\Alternative drives	3	0	0	0
Future Mobility\Innovative mobility combined with housing	2	0	2	0
Future Mobility\Increased importance of cycling	0	0	0	0
Future Mobility\New pricing models for mobility providers	0	0	0	0
Future Mobility\Mobility as municipal service	2	0	0	2
Future Mobility\Non-profit, open source	0	0	2	0
Future Mobility\Users value intermodal routing	0	0	0	0
Future Mobility\Mobility niches with innovative means of transport	0	0	0	2
Future Mobility\Requirements for innovation projects	0	0	0	0
Future Mobility\Gather low mobility innovation	0	0	0	0
Future Mobility\Cooperation between transport companies	0	0	0	0
New Mobility\Sustainability Strategies				
Sustainability Strategies\Intermodal mobility platform for sustainable mobility	0	0	2	0
Sustainability Strategies\User-centricity of the mobility platform	0	0	0	4
Sustainability Strategies\Optimization with regard to ecological sustainability	0	2	2	0
Sustainability Strategies\MIT is explicitly disadvantaged	0	0	0	0
New Mobility\Long-term Mobility Transformation				
Long-term Mobility Transformation\Holistic transformation of the transportation system	7	2	2	5
Long-term Mobility Transformation\Social acceptance	2	0	0	5
Long-term Mobility Transformation\Long-term promotion of MIT alternatives	0	0	2	0
Long-term Mobility Transformation\Transformation to regional mobility providers	0	0	0	2
Long-term Mobility Transformation\Thinking mobility across Germany or Europe	2	2	2	0
Long-term Mobility Transformation\Demand-driven mobility solutions	2	0	0	0
Long-term Mobility Transformation\Fully sustainable mobility is virtually impossible	0	0	0	0
Long-term Mobility Transformation\Change towards centralization of transport associations	0	0	0	0
Long-term Mobility Transformation\Singularity of MIT does not change	0	0	0	0
Mobility Behavior				
Mobility Behavior\Current Mobility Behavior				
Current Mobility Behavior\Relevance of the car	10	0	0	5
Current Mobility Behavior\Comfort as the most important factor	0	2	2	0
Current Mobility Behavior\MIT more popular than public transport	4	0	0	2
Current Mobility Behavior\Aversions against public transport	0	0	0	0
Current Mobility Behavior\General targetgroup of innovative mobility	0	0	0	0
Current Mobility Behavior\General resentments	0	0	0	2
Current Mobility Behavior\Transfers as a barrier to transport	0	0	0	0
Current Mobility Behavior\Ecological sustainability unimportant for customers	0	2	2	0
Current Mobility Behavior\Individual transport attractive for first and last mile	0	0	0	2
Current Mobility Behavior\Popularity of the bicycle	0	0	0	0
Current Mobility Behavior\Mobility in non-public spaces	0	0	0	2
Current Mobility Behavior\Carpooling services are currently not used	0	0	0	0
Current Mobility Behavior\Differences between urban and rural areas	0	0	0	0
Mobility Behavior\Future Mobility Behavior				
Future Mobility Behavior\Expectation of live data	0	0	0	2
Future Mobility Behavior\Intermodality as a rival to the car	0	0	0	0
Future Mobility Behavior\Positive view of intermodality	0	0	0	0
Future Mobility Behavior\Mobility platforms for the best route	0	0	0	0
Mobility Behavior\Influences on Mode Choice				
Influences on Mode Choice\Perception of mobility costs	2	0	0	0
Influences on Mode Choice\Low visibility of public transport for MIT users	0	0	0	0
Mobility Behavior\Remote Work				
Remote Work\Reduced mobility through remote work	0	0	2	0
Remote Work\Shift in mobility through remote work	0	0	0	0
Mobility Planning and Needs				
Mobility Planning and Needs\Needs, Identification and Problems				
Needs, Identification and Problems\Key metrics for mobility needs	4	2	2	2
Needs, Identification and Problems\User mobility behavior is not tracked	5	0	0	6
Needs, Identification and Problems\User mobility behavior is tracked	0	0	0	0
Needs, Identification and Problems\Local data for traffic and transportation planning	4	0	0	4
Needs, Identification and Problems\Impulses for simulation	5	0	0	2
Needs, Identification and Problems\Low GPS data for demand response planning	0	2	0	0
Needs, Identification and Problems\Funding models for public transportation not sustainable	0	5	5	0
Needs, Identification and Problems\Empty trips	2	0	0	2
Needs, Identification and Problems\Small-scale mobility solutions	0	0	2	0
Needs, Identification and Problems\Demand distribution unfavorable for planning	3	0	3	0
Needs, Identification and Problems\A shift to freer data access is needed	0	0	0	0
Needs, Identification and Problems\Simple code base	0	0	0	0
Needs, Identification and Problems\Lack of business and end user education	0	0	0	0
Needs, Identification and Problems\Large events as short-term demand shocks	0	0	0	0
Needs, Identification and Problems\Competition within the industry	0	0	0	0
Needs, Identification and Problems\Non-public mobility space	0	0	0	0
Needs, Identification and Problems\Corporate social responsibility	0	0	0	0
Needs, Identification and Problems\Legal restrictions against individual motorized traffic	0	0	0	0
Needs, Identification and Problems\Planning Problems	0	0	0	0
Mobility Planning and Needs\Future Scenarios in Planning				
Future Scenarios in Planning\Mobility as a service scenario	4	6	3	5
Future Scenarios in Planning\Local mobility provider scenario	2	0	0	0
Future Scenarios in Planning\AV routing scenario	0	0	2	0
Future Scenarios in Planning\CO2 neutrality	0	0	0	0
Future Scenarios in Planning\Bundling mobility services through apps	0	0	0	0
Future Scenarios in Planning\SUV IT-dominance scenario	0	0	0	0
Framework Conditions				
Framework Conditions\Economic Framework Conditions				
Economic Framework Conditions\Transport companies have their own business interests	2	0	0	0
Economic Framework Conditions\Research collaborations	0	0	2	2
Economic Framework Conditions\Legal Basis	0	0	0	2
Economic Framework Conditions\No live data from transport associations	0	0	0	0
Economic Framework Conditions\Competition from US companies	0	0	0	0
Framework Conditions\Technical Framework Conditions				
Technical Framework Conditions\Insufficient data	7	0	0	2
Technical Framework Conditions\Insufficient infrastructure	4	2	4	4
Technical Framework Conditions\Algorithms are not powerful enough	0	0	0	2
Technical Framework Conditions\Insufficient data quality	5	0	0	2
Technical Framework Conditions\Technical risks / limitations of new forms of mobility	0	0	0	0
Technical Framework Conditions\Technical interfaces with existing infrastructure	0	0	2	0
Framework Conditions\Government Framework Conditions				
Government Framework Conditions\Budget for public transport	2	2	4	0
Government Framework Conditions\Decentralization of public transport	0	2	2	2
Government Framework Conditions\Public transportation as a service of general interest	0	0	0	0
Government Framework Conditions\Public authorities must act without direct intention	0	2	2	2
Government Framework Conditions\Tax measures / incentive policies	0	0	0	0
Government Framework Conditions\No legal framework for shared data	0	0	0	0
Government Framework Conditions\Right to work from home influences mode choice	0	0	2	0
Government Framework Conditions\No awareness of open data in public administration	0	0	0	0
Government Framework Conditions\No operator structures for open-source products	0	0	0	0
Government Framework Conditions\Lengthy setup in other municipalities	0	0	0	0
Government Framework Conditions\Security as a framework condition of public space	0	0	0	0

Fig. 25. Code Relation Table Current Mobility Services.

New mobility

Codesystem	Improving innovative mobility services	Integration of new mobility services into existing ones	Limitations of non-MIT solutions	Intermodal mobility platform for sustainable mobility
Mobility and Corona				
Mobility and Corona\Change in Users' Mobility Behavior				
Change in Users' Mobility Behavior\Decline in public transport and shorter ons	0	0	5	0
Change in Users' Mobility Behavior\Return to pre-pandemic mobility behavior	2	2	0	0
Change in Users' Mobility Behavior\Individual alternatives to motorized transportation	0	0	2	0
Change in Users' Mobility Behavior\Importance of hygiene on public transportation	0	2	0	0
Change in Users' Mobility Behavior\Working from home reduces mobility requirements	0	0	0	0
Change in Users' Mobility Behavior\Decline in tourist travel	0	0	0	0
Mobility and Corona\Direct Impact of the Pandemic on Transport Companies				
Direct Impact of the Pandemic on Transport Companies\Competitive disadvantages for new businesses	0	2	2	0
Direct Impact of the Pandemic on Transport Companies\Delay in practical research on mobility	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Positive effects/no disadvantages due to Covid	2	3	2	0
Direct Impact of the Pandemic on Transport Companies\Corona insecurity as a barrier to mobility development	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Adjustment of public transport hrs	0	3	0	2
Direct Impact of the Pandemic on Transport Companies\Positive impact on motorized individual transport	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\More cooperation between mobility providers	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Decline in a automotive industry even before Corona	0	0	0	0
Current Mobility Services				
Current Mobility Service\Conventional Means of Transportation				
Conventional Means of Transportation\Limitations of conventional means of transportation	0	5	5	0
Conventional Means of Transportation\Decentralized structure of public transport	0	0	0	0
Conventional Means of Transportation\Improving the mobility offer with conventional solutions	0	2	0	0
Conventional Means of Transportation\Financial limitations of public transport	0	0	0	0
Conventional Means of Transportation\Restriction of other road users by MIT	0	0	0	0
Current Mobility Services\Innovative Transportation Solutions already in Use				
Innovative Transportation Solutions already in Use\Sharing solutions	0	2	4	0
Innovative Transportation Solutions already in Use\Current approaches to intermodal mobility	0	3	2	0
Innovative Transportation Solutions already in Use\Supplementing the conventional mobility offering	2	5	2	2
Innovative Transportation Solutions already in Use\Pilot projects with municipalities	0	2	4	0
Innovative Transportation Solutions already in Use\On demand principle	2	5	2	0
New Mobility				
New Mobility\Future Mobility				
Future Mobility\Improving innovative mobility services	0	14	5	0
Future Mobility\Integration of new mobility services into existing ones	14	0	5	5
Future Mobility\Limitations of non-MIT solutions	5	5	0	0
Future Mobility\Alternative drives	0	0	5	0
Future Mobility\Innovative mobility combined with housing	0	0	0	4
Future Mobility\Increased importance of cycling	0	3	3	2
Future Mobility\New pricing models for mobility providers	0	4	0	3
Future Mobility\Mobility as a municipal service	0	0	0	3
Future Mobility\Non-profit, open source	0	3	0	2
Future Mobility\Users value intermodal routing	2	4	0	2
Future Mobility\Mobility niches with innovative means of transport	2	2	2	0
Future Mobility\Requirements for innovation projects	0	0	2	0
Future Mobility\Rather low mobility innovation	0	0	0	0
Future Mobility\Cooperation between transport companies	0	0	0	0
New Mobility\Sustainability Strategies				
Sustainability Strategies\Intermodal mobility platform for sustainable mobility	0	5	0	0
Sustainability Strategies\User-centricity of the mobility platform	0	0	4	0
Sustainability Strategies\Optimization with regard to ecological sustainability	4	4	4	0
Sustainability Strategies\MIT is explicitly disadvantaged	0	0	0	2
New Mobility\Long-term Mobility Transformation				
Long-term Mobility Transformation\Holistic transformation of the transportation system	2	3	0	2
Long-term Mobility Transformation\Social acceptance	2	3	5	0
Long-term Mobility Transformation\Long-term promotion of MIT alternatives	0	3	0	2
Long-term Mobility Transformation\Transformation to regional mobility providers	0	0	4	4
Long-term Mobility Transformation\Thinking mobility across Germany or Europe	0	2	2	2
Long-term Mobility Transformation\Demand-driven mobility solutions	2	3	0	0
Long-term Mobility Transformation\Fully sustainable mobility is virtually impossible	0	0	0	0
Long-term Mobility Transformation\Change towards centralization of transport associations	0	0	0	0
Long-term Mobility Transformation\Popularity of MIT does not change	0	0	0	0
Mobility Behavior				
Mobility Behavior\Current Mobility Behavior				
Current Mobility Behavior\Relevance of the car	2	0	5	0
Current Mobility Behavior\Comfort as the most important factor	0	0	2	2
Current Mobility Behavior\MIT more popular than public transport	0	0	2	0
Current Mobility Behavior\Aversions against public transport	0	0	0	0
Current Mobility Behavior\Special target group of innovative mobility	0	0	0	0
Current Mobility Behavior\General resentments	0	0	2	0
Current Mobility Behavior\Transfers as a barrier to transport	0	0	0	0
Current Mobility Behavior\Ecological sustainability unimportant for customers	0	0	2	0
Current Mobility Behavior\Individual transport attractive for first and last mile	0	0	2	0
Current Mobility Behavior\Popularity of the bicycle	0	0	0	0
Current Mobility Behavior\Mobility in non-public spaces	0	0	2	0
Current Mobility Behavior\Carpooling services are currently not used	0	0	0	0
Current Mobility Behavior\Differences between urban and rural areas	0	0	0	0
Mobility Behavior\Future Mobility Behavior				
Future Mobility Behavior\Expectation of live data	0	0	0	0
Future Mobility Behavior\Intermodality as a rival to the car	0	0	0	10
Future Mobility Behavior\Positive view of intermodality	0	0	0	2
Future Mobility Behavior\Mobility platforms for the best route	0	0	0	1
Mobility Behavior\Influences on Mode Choice				
Influences on Mode Choice\Perception of mobility costs	2	2	0	0
Influences on Mode Choice\Low visibility of public transport for MIT users	0	0	0	0
Mobility Behavior\Remote Work				
Remote Work\Reduced mobility through remote work	0	3	0	2
Remote Work\Shift in mability through remote work	2	2	0	0
Mobility Planning and Needs				
Mobility Planning and Needs\Needs, Identification and Problems				
Needs, Identification and Problems\Key metrics for mobility needs	2	0	4	0
Needs, Identification and Problems\User mobility behavior is not tracked	0	0	4	2
Needs, Identification and Problems\User mobility behavior is tracked	0	0	0	0
Needs, Identification and Problems\Local data for traffic and transportation planning	2	2	4	3
Needs, Identification and Problems\Impulses for simulation	0	2	2	0
Needs, Identification and Problems\Live-GTFS data for demand responsive planning	0	0	0	0
Needs, Identification and Problems\Funding models for public transportation not sustainable	0	0	0	0
Needs, Identification and Problems\Empty trips	0	4	2	4
Needs, Identification and Problems\Small-scale mobility solutions	0	5	2	4
Needs, Identification and Problems\Demand distribution unfavorable for planning	0	0	2	0
Needs, Identification and Problems\A shift to freer data access is needed	0	0	0	4
Needs, Identification and Problems\Simple code base	0	0	0	4
Needs, Identification and Problems\Lack of business and end user education	0	0	2	0
Needs, Identification and Problems\Large events as short-term demand checks	0	0	2	0
Needs, Identification and Problems\Competition within the industry	0	0	0	0
Needs, Identification and Problems\Non-public mobility space	0	0	2	0
Needs, Identification and Problems\Corporate social responsibility	2	0	2	0
Needs, Identification and Problems\Legal restrictions against individual motorized traffic	0	0	0	0
Needs, Identification and Problems\Planning Problems	0	0	0	0
Mobility Planning and Needs\Future Scenarios in Planning				
Future Scenarios in Planning\Mobility as a service scenario	0	7	7	14
Future Scenarios in Planning\Local mobility provider scenario	2	3	0	0
Future Scenarios in Planning\AV routing scenario	0	3	2	9
Future Scenarios in Planning\CO2 neutrality	2	0	2	6
Future Scenarios in Planning\Bundling mobility services through ones	4	0	0	0
Future Scenarios in Planning\ÖSIT dominance scenario	0	0	0	2
Framework Conditions				
Framework Conditions\Economic Framework Conditions				
Economic Framework Conditions\Transport companies have their own business interests	0	0	5	9
Economic Framework Conditions\Research collaborations	0	3	0	2
Economic Framework Conditions\Legal Basis	0	0	0	0
Economic Framework Conditions\No live data from transport associations	0	0	0	0
Economic Framework Conditions\Competition from US companies	0	0	0	2
Framework Conditions\Technical Framework Conditions				
Technical Framework Conditions\Insufficient data	2	2	3	3
Technical Framework Conditions\Insufficient infrastructure	0	3	4	2
Technical Framework Conditions\Algorithms are not powerful enough	0	0	0	12
Technical Framework Conditions\Insufficient data quality	0	0	2	0
Technical Framework Conditions\Technical risks / limitations of new forms of mobility	0	0	2	0
Technical Framework Conditions\Technical interfaces with existing infrastructure	0	0	2	0
Framework Conditions\Government Framework Conditions				
Government Framework Conditions\Budget for public transport too small	0	5	6	2
Government Framework Conditions\Decentralization of public transport	0	0	4	0
Government Framework Conditions\Public transportation as a service of general interest	0	0	1	0
Government Framework Conditions\Public authorities must act without absolute mandate	0	0	2	1
Government Framework Conditions\Tax measures / incentive policies	1	1	0	0
Government Framework Conditions\No legal framework for float data	0	0	0	4
Government Framework Conditions\Right to work from home influences mode choice	0	4	0	1
Government Framework Conditions\No awareness of open data in public administration	0	0	2	1
Government Framework Conditions\No operator structures for open source products	0	0	0	0
Government Framework Conditions\Lengthy setup in other municipalities	0	0	0	0
Government Framework Conditions\Security as a framework condition of public space	0	0	2	0

Fig. 26. Code Relation Table for New Mobility.

Mobility behavior

Codesystem	Relevance of the car	Comfort as the most important factor	MIT more popular than public transport	Perception of mobility costs
Mobility and Corona				
Mobility and Corona\Change in Users' Mobility Behavior				
Change in Users' Mobility Behavior\Decline in public transport and sharing use	2	0	2	0
Change in Users' Mobility Behavior\Return to pre-pandemic mobility behavior	0	0	5	2
Change in Users' Mobility Behavior\Individual alternatives to motorized transportation	0	0	2	0
Change in Users' Mobility Behavior\Importance of hygiene on public transportation	0	0	0	0
Change in Users' Mobility Behavior\Working from home reduces mobility requirements	0	0	0	0
Change in Users' Mobility Behavior\Decline in tourist travel	0	0	2	0
Mobility and Corona\Direct Impact of the Pandemic on Transport Companies				
Direct Impact of the Pandemic on Transport Companies\Competitive disadvantages for new businesses	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Delay in practical research on mobility	0	0	0	2
Direct Impact of the Pandemic on Transport Companies\Positive effects/no disadvantages due to Covid	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Corona insecurity as a barrier to mobility development	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Adjustment of public transport fares	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Positive impact on motorized individual transport	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\More cooperation between mobility providers	0	0	0	0
Direct Impact of the Pandemic on Transport Companies\Decline in automotive industry even before Corona	0	0	2	0
Current Mobility Services				
Current Mobility Services\Conventional Means of Transportation				
Conventional Means of Transportation\Limitations of conventional means of transportation	10	0	4	2
Conventional Means of Transportation\Decentralized structure of public transport	2	0	0	0
Conventional Means of Transportation\Improving the mobility offer with conventional solutions	0	0	0	0
Conventional Means of Transportation\Financial limitations of public transport	0	0	0	0
Conventional Means of Transportation\Restriction of other road users by MIT	0	0	0	0
Current Mobility Services\Innovative Transportation Solutions already in Use				
Innovative Transportation Solutions already in Use\Sharing solutions	0	2	3	4
Innovative Transportation Solutions already in Use\Current approaches to intermodal mobility	0	2	0	0
Innovative Transportation Solutions already in Use\Supplementing the conventional mobility offering	0	2	0	0
Innovative Transportation Solutions already in Use\Pilot projects with municipalities	5	0	2	0
Innovative Transportation Solutions already in Use\On demand principle	0	0	0	0
New Mobility				
New Mobility\Future Mobility				
Future Mobility\Improving innovative mobility services	2	0	0	2
Future Mobility\Integration of new mobility services into existing ones	0	0	0	2
Future Mobility\Limitations of non-MIT solutions	5	2	2	0
Future Mobility\Alternative drives	0	0	0	0
Future Mobility\Innovative mobility combined with housing	3	2	2	0
Future Mobility\Increased importance of cycling	0	0	2	0
Future Mobility\New pricing models for mobility providers	0	0	0	0
Future Mobility\Mobility as municipal service	0	0	0	2
Future Mobility\Non-profit, open source	0	0	0	0
Future Mobility\Users value intermodal routing	3	0	2	0
Future Mobility\Mobility niches with innovative means of transport	0	0	0	0
Future Mobility\Requirements for innovation projects	0	0	0	0
Future Mobility\Rather low mobility innovation	0	0	0	0
Future Mobility\Cooperation between transport companies	0	0	0	0
New Mobility\Sustainability Strategies				
Sustainability Strategies\Intermodal mobility platform for sustainable mobility	6	2	4	0
Sustainability Strategies\User-centricity of the mobility platform	0	0	0	0
Sustainability Strategies\Optimization with regard to ecological sustainability	0	2	0	4
Sustainability Strategies\MIT is explicitly disadvantaged	5	0	2	0
New Mobility\Long-term Mobility Transformation				
Long-term Mobility Transformation\Holistic transformation of the transportation system	6	0	3	0
Long-term Mobility Transformation\Social acceptance	7	0	0	0
Long-term Mobility Transformation\Long-term promotion of MIT alternatives	2	0	0	0
Long-term Mobility Transformation\Transformation to regional mobility providers	0	0	0	0
Long-term Mobility Transformation\Thinking mobility across Germany or Europe	0	0	0	2
Long-term Mobility Transformation\Demand-driven mobility solutions	0	0	0	0
Long-term Mobility Transformation\Fully sustainable mobility is virtually impossible	3	0	0	0
Long-term Mobility Transformation\Change towards centralization of transport associations	2	0	0	0
Long-term Mobility Transformation\Popularity of MIT does not change	0	0	2	0
Mobility Behavior				
Mobility Behavior\Current Mobility Behavior				
Current Mobility Behavior\Relevance of the car	0	3	16	2
Current Mobility Behavior\Comfort as the most important factor	3	0	2	4
Current Mobility Behavior\MIT more popular than public transport	14	2	0	3
Current Mobility Behavior\Aversions against public transport	11	0	4	0
Current Mobility Behavior\Special target group of innovative mobility	2	0	0	0
Current Mobility Behavior\General resentments	8	6	5	0
Current Mobility Behavior\Transfers as a barrier to transport	0	7	0	0
Current Mobility Behavior\Ecological sustainability unimportant for customers	0	2	0	0
Current Mobility Behavior\Individual transport attractive for first and last mile	3	0	7	0
Current Mobility Behavior\Popularity of the bicycle	0	0	0	0
Current Mobility Behavior\Mobility in non-public spaces	0	0	0	0
Current Mobility Behavior\Carpooling services are currently not used	0	0	0	0
Current Mobility Behavior\Differences between urban and rural areas	2	0	0	0
Mobility Behavior\Future Mobility Behavior				
Future Mobility Behavior\Expectation of live data				
Future Mobility Behavior\Intermodality as a rival to the car	3	2	2	0
Future Mobility Behavior\Positive view of intermodality	3	0	2	0
Future Mobility Behavior\Mobility platforms for the best route	0	0	0	0
Mobility Behavior\Influences on Mode Choice				
Influences on Mode Choice\Perception of mobility costs	2	4	3	0
Influences on Mode Choice\Low visibility of public transport for MIT users	0	0	0	0
Mobility Behavior\Remote Work				
Remote Work\Reduced mobility through remote work	0	0	2	0
Remote Work\Shift in mobility through remote work	0	0	2	2
Mobility Planning and Needs				
Mobility Planning and Needs\Needs, Identification and Problems				
Needs, Identification and Problems\Key metrics for mobility needs	5	0	6	5
Needs, Identification and Problems\User mobility behavior is not tracked	12	0	10	4
Needs, Identification and Problems\User mobility behavior is tracked	0	0	0	0
Needs, Identification and Problems\Local data for traffic and transportation planning	8	0	6	2
Needs, Identification and Problems\Impulses for simulation	6	0	5	3
Needs, Identification and Problems\Live GTFS data for demand response planning	0	0	0	0
Needs, Identification and Problems\Funding models for public transportation not sustainable	0	0	0	0
Needs, Identification and Problems\Empty trips	2	0	0	0
Needs, Identification and Problems\Small-scale mobility solutions	0	0	0	0
Needs, Identification and Problems\Demand distribution unfavorable for planning	0	0	0	0
Needs, Identification and Problems\AI shift to freer data access is needed	0	0	0	0
Needs, Identification and Problems\Simple code base	0	0	0	0
Needs, Identification and Problems\Lack of business and end user education	0	0	0	0
Needs, Identification and Problems\Large events as short-term demand shocks	0	0	0	0
Needs, Identification and Problems\Competition within the industry	0	0	0	0
Needs, Identification and Problems\Non-public mobility space	0	0	0	0
Needs, Identification and Problems\Corporate social responsibility	0	0	0	0
Needs, Identification and Problems\Legal restrictions against individual motorized traffic	0	0	0	0
Needs, Identification and Problems\Planning Problems	0	0	0	0
Mobility Planning and Needs\Future Scenarios in Planning				
Future Scenarios in Planning\Mobility as a service scenario	5	5	4	0
Future Scenarios in Planning\Local mobility provider scenario	0	0	0	0
Future Scenarios in Planning\AI routing scenario	5	0	2	0
Future Scenarios in Planning\CO2 neutrality	0	0	0	0
Future Scenarios in Planning\Bundling mobility services through apps	0	0	0	0
Future Scenarios in Planning\US IT dominance scenario	3	0	2	0
Framework Conditions				
Framework Conditions\Economic Framework Conditions				
Economic Framework Conditions\Transport companies have their own business interests	5	0	7	0
Economic Framework Conditions\Research collaborations	0	0	0	0
Economic Framework Conditions\Legal Basis	0	0	0	0
Economic Framework Conditions\No live data from transport associations	0	0	0	0
Economic Framework Conditions\Competition from US companies	3	0	2	0
Framework Conditions\Technical Framework Conditions				
Technical Framework Conditions\Insufficient data	10	0	10	1
Technical Framework Conditions\Insufficient infrastructure	3	0	2	0
Technical Framework Conditions\Algorithms are not powerful enough	4	0	3	0
Technical Framework Conditions\Insufficient data quality	9	0	7	3
Technical Framework Conditions\Technical risks / limitations of new forms of mobility	0	0	0	0
Technical Framework Conditions\Technical interfaces with existing infrastructure	0	2	0	0
Framework Conditions\Government Framework Conditions				
Government Framework Conditions\Budget for public transport too small	2	0	0	0
Government Framework Conditions\Decentralization of public transport	5	0	2	0
Government Framework Conditions\Public transportation as a service of general interest	0	0	0	0
Government Framework Conditions\Public authorities must act without discrimination	5	0	2	0
Government Framework Conditions\Tax measures / incentive policies	0	0	0	3
Government Framework Conditions\No legal framework for (live) data	3	0	2	0
Government Framework Conditions\Right to work from home influences mode choice	0	0	0	0
Government Framework Conditions\No awareness of open data in public administration	0	0	0	0
Government Framework Conditions\No operator structures for open source products	0	0	0	0
Government Framework Conditions\Lengthy setup in other municipalities	0	0	0	0
Government Framework Conditions\Security as a framework condition of public space	0	0	0	0

Fig. 27. Code Relations Table for Mobility Behavior.

Mobility planning and needs

Codesystem	Key metrics for mobility needs	User mobility behavior is not tracked	Mobility as a service scenario
Mobility and Corona			
Mobility and Corona\Change in Users' Mobility Behavior			
Change in Users' Mobility Behavior\Decline in public transport and sharing use	2	0	0
Change in Users' Mobility Behavior\Return to pre-pandemic mobility behavior	0	0	0
Change in Users' Mobility Behavior\Individual alternatives to motorized transportation	0	0	0
Change in Users' Mobility Behavior\Importance of hygiene on public transportation	0	2	3
Change in Users' Mobility Behavior\Working from home reduces mobility requirements	0	0	0
Change in Users' Mobility Behavior\Decline in tourist travel	0	0	0
Mobility and Corona\Direct Impact of the Pandemic on Transport Companies			
Direct Impact of the Pandemic on Transport Companies\Competitive disadvantages for new businesses	2	3	0
Direct Impact of the Pandemic on Transport Companies\Delay in practical research on mobility	0	2	0
Direct Impact of the Pandemic on Transport Companies\Positive effects/no disadvantages due to Covid	0	0	2
Direct Impact of the Pandemic on Transport Companies\Corona insecurity as a barrier to mobility development	0	0	0
Direct Impact of the Pandemic on Transport Companies\Adjustment of public transport fares	0	0	0
Direct Impact of the Pandemic on Transport Companies\Positive impact on motorized individual transport	2	0	0
Direct Impact of the Pandemic on Transport Companies\More cooperation between mobility providers	0	0	0
Direct Impact of the Pandemic on Transport Companies\Decline in automotive industry were before Corona	0	0	0
Current Mobility Services			
Current Mobility Services\Conventional Means of Transportation			
Conventional Means of Transportation\Limitations of conventional means of transportation	4	5	4
Conventional Means of Transportation\Decentralized structure of public transport	0	0	0
Conventional Means of Transportation\Improving the mobility offer with conventional solutions	0	0	0
Conventional Means of Transportation\Financial limitations of public transport	3	0	0
Conventional Means of Transportation\Restriction of other road users by MIT	2	0	0
Current Mobility Services\Innovative Transportation Solutions already in Use			
Innovative Transportation Solutions already in Use\Sharing solutions	7	4	8
Innovative Transportation Solutions already in Use\Current approaches to intermodal mobility	2	0	6
Innovative Transportation Solutions already in Use\Supplementing the conventional mobility offering	2	0	9
Innovative Transportation Solutions already in Use\Pilot projects with municipalities	2	6	6
Innovative Transportation Solutions already in Use\On-demand principle	0	0	2
New Mobility			
New Mobility\Future Mobility			
Future Mobility\Improving innovative mobility services	2	0	5
Future Mobility\Integration of new mobility services into existing ones	0	0	7
Future Mobility\Limitations of non-MIT solutions	4	4	7
Future Mobility\Alternative drives	0	0	0
Future Mobility\Innovative mobility combined with housing	2	0	0
Future Mobility\Increased importance of cycling	0	0	0
Future Mobility\New pricing models for mobility providers	0	0	0
Future Mobility\Mobility as municipal service	0	3	7
Future Mobility\Non-profit, open source	0	0	0
Future Mobility\Users value intermodal routing	0	2	0
Future Mobility\Mobility riches with innovative means of transport	0	2	2
Future Mobility\Requirements for innovation projects	0	0	2
Future Mobility\Rather low mobility innovation	0	0	0
Future Mobility\Cooperation between transport companies	0	0	0
New Mobility\Sustainability Strategies			
Sustainability Strategies\Intermodal mobility platform for sustainable mobility	0	2	14
Sustainability Strategies\User-centricity of the mobility platform	0	4	11
Sustainability Strategies\Optimization with regard to ecological sustainability	0	0	5
Sustainability Strategies\MIT is explicitly disadvantaged	0	2	0
New Mobility\Long-term Mobility Transformation	2		
long-term Mobility Transformation\Holistic transformation of the transportation system	5	5	6
Long-term Mobility Transformation\Social acceptance	0	6	7
Long-term Mobility Transformation\Long-term promotion of MIT alternatives	0	0	0
Long-term Mobility Transformation\Transformation to regional mobility providers	0	2	4
Long-term Mobility Transformation\Thinking mobility across Germany or Europe	4	0	2
Long-term Mobility Transformation\Demand-driven mobility solutions	2	0	4
Long-term Mobility Transformation\Fully sustainable mobility is virtually impossible	0	0	0
Long-term Mobility Transformation\Change towards centralization of transport associations	0	0	0
Long-term Mobility Transformation\Popularity of MIT does not change	0	0	0
Mobility Behavior			
Mobility Behavior\Current Mobility Behavior			
Current Mobility Behavior\Relevance of the car	5	12	3
Current Mobility Behavior\Comfort as the most important factor	0	0	5
Current Mobility Behavior\MIT more popular than public transport	4	10	4
Current Mobility Behavior\Aversions against public transport	0	3	4
Current Mobility Behavior\Special target group of innovative mobility	0	0	0
Current Mobility Behavior\General resentments	0	2	2
Current Mobility Behavior\Transfers as a barrier to transport	0	0	0
Current Mobility Behavior\Ecological sustainability unimportant for customers	0	0	3
Current Mobility Behavior\Individual transport attractive for first and last mile	0	2	4
Current Mobility Behavior\Popularity of the bicycle	0	0	0
Current Mobility Behavior\Mobility in non-public spaces	2	2	4
Current Mobility Behavior\Carpooling services are currently not used	2	0	2
Current Mobility Behavior\Differences between urban and rural areas	0	0	0
Mobility Behavior\Future Mobility Behavior			
Future Mobility Behavior\Expectation of live data	0	2	5
Future Mobility Behavior\Intermodality as a rival to the car	0	0	6
Future Mobility Behavior\Positive view of intermodality	0	2	0
Future Mobility Behavior\Mobility platforms for the best route	0	0	4
Mobility Behavior\Influences on Mode Choice			
Influences on Mode Choice\Perception of mobility costs	5	4	0
Influences on Mode Choice\Low visibility of public transport for MIT users	0	0	0
Mobility Behavior\Remote Work			
Remote Work\Reduced mobility through remote work	0	0	0
Remote Work\Shift in mobility through remote work	0	0	0
Mobility Planning and Needs			
Mobility Planning and Needs\Needs, Identification and Problems			
Needs, Identification and Problems\Key metrics for mobility needs	0	9	2
Needs, Identification and Problems\User mobility behavior is not tracked	9	0	8
Needs, Identification and Problems\User mobility behavior is tracked	3	0	4
Needs, Identification and Problems\Local data for traffic and transportation planning	2	7	11
Needs, Identification and Problems\Impulses for simulation	4	9	5
Needs, Identification and Problems\Use GTFS data for demand response planning	2	2	0
Needs, Identification and Problems\Funding models for public transportation not sustainable	5	0	0
Needs, Identification and Problems\Empty trips	0	3	5
Needs, Identification and Problems\Small-scale mobility solutions	0	0	4
Needs, Identification and Problems\Demand distribution unfavorable for planning	0	0	0
Needs, Identification and Problems\A shift to freer data access is needed	0	0	5
Needs, Identification and Problems\Simple code base	0	0	4
Needs, Identification and Problems\Lack of business and end user adoption	0	0	2
Needs, Identification and Problems\Large events as short-term demand shocks	0	0	0
Needs, Identification and Problems\Competition within the industry	0	0	0
Needs, Identification and Problems\Non-public mobility space	0	0	7
Needs, Identification and Problems\Corporate social responsibility	2	0	0
Needs, Identification and Problems\Legal restrictions against individual motorized traffic	0	0	0
Needs, Identification and Problems\Planning Problems	0	0	0
Mobility Planning and Needs\Future Scenarios in Planning			
Future Scenarios in Planning\Mobility as a service scenario	2	8	0
Future Scenarios in Planning\Local mobility provider scenario	0	0	2
Future Scenarios in Planning\AI routing scenario	0	2	4
Future Scenarios in Planning\ESG mobility	2	0	3
Future Scenarios in Planning\Bundling mobility services through apps	0	0	0
Future Scenarios in Planning\US IT dominance scenario	0	2	0
Framework Conditions			
Framework Conditions\Economic Framework Conditions			
Economic Framework Conditions\Transport companies have their own business interests	0	5	15
Economic Framework Conditions\Research collaborations	0	1	4
Economic Framework Conditions\Legal Basis	0	2	3
Economic Framework Conditions\No live data from transport associations	0	0	0
Economic Framework Conditions\Competition from US companies	0	2	0
Framework Conditions\Technical Framework Conditions			
Technical Framework Conditions\Insufficient data	4	16	0
Technical Framework Conditions\Insufficient infrastructure	4	4	2
Technical Framework Conditions\Algorithms are not powerful enough	0	5	10
Technical Framework Conditions\Insufficient data quality	0	13	3
Technical Framework Conditions\Technical risks / limitations of new forms of mobility	0	0	0
Technical Framework Conditions\Technical interfaces with existing infrastructure	0	0	3
Framework Conditions\Government Framework Conditions			
Government Framework Conditions\Budget for public transport too small	2	0	0
Government Framework Conditions\Decentralization of public transport	4	2	0
Government Framework Conditions\Public transportation as a service of general interest	0	0	0
Government Framework Conditions\Public authorities must act without discrimination	4	2	0
Government Framework Conditions\Tax measures / incentive policies	2	0	0
Government Framework Conditions\No legal framework for (live) data	0	2	2
Government Framework Conditions\Right to work from home influences mode choice	0	0	0
Government Framework Conditions\No awareness of open data in public administration	0	0	6
Government Framework Conditions\No operator structures for open-source products	0	0	0
Government Framework Conditions\Lengthy setup in other municipalities	0	0	0
Government Framework Conditions\Security as a framework condition of public space	0	0	2

Fig. 28. Code Relations Table for Mobility Planning and Needs.

Framework conditions

Codesystem	Transport companies have their own business inter-ests	Insufficient data	Insufficient infrastructure
Mobility and Corona			
Mobility and Corona\Change in Users' Mobility Behavior			
Change in Users' Mobility Behavior\Decline in public transport and shortin-cone	2	0	2
Change in Users' Mobility Behavior\Return to pre-pandemic mobility behavior	0	0	0
Change in Users' Mobility Behavior\Individual alternatives to motorized transportation	0	0	2
Change in Users' Mobility Behavior\Importance of hygiene on public transportation	3	2	0
Change in Users' Mobility Behavior\Working from home reduces mobility requirements	0	0	0
Change in Users' Mobility Behavior\Decline in tourist travel	0	0	0
Mobility and Corona\Direct Impact of the Pandemic on Transport Companies			
Direct Impact of the Pandemic on Transport Companies\Competitive disadvantages for new businesses	0	2	0
Direct Impact of the Pandemic on Transport Companies\Delay in practical research on mobility	0	2	0
Direct Impact of the Pandemic on Transport Companies\Positive effects/no disadvantages due to Covid	0	0	0
Direct Impact of the Pandemic on Transport Companies\Corona insecurity as a barrier to mobility development	0	0	0
Direct Impact of the Pandemic on Transport Companies\Adjustment of public transport fares	0	0	2
Direct Impact of the Pandemic on Transport Companies\Positive impact on motorized individual transport	0	0	0
Direct Impact of the Pandemic on Transport Companies\More cooperation between mobility providers	0	0	0
Direct Impact of the Pandemic on Transport Companies\Decline in automotive industry even before Corona	0	0	0
Current Mobility Services			
Current Mobility Services\Conventional Means of Transportation			
Conventional Means of Transportation\Limitations of conventional means of transportation	2	7	4
Conventional Means of Transportation\Decentralized structure of public transport	0	0	2
Conventional Means of Transportation\Improving the mobility offer with conventional solutions	0	0	0
Conventional Means of Transportation\Financial limitations of public transport	0	0	3
Conventional Means of Transportation\Restriction of other road users by MIT	0	0	0
Current Mobility Services\Innovative Transportation Solutions already in Use			
Innovative Transportation Solutions already in Use\Sharing solutions	0	3	0
Innovative Transportation Solutions already in Use\Current approaches to intermodal mobility	0	0	2
Innovative Transportation Solutions already in Use\Supplementing the conventional mobility offering	0	0	4
Innovative Transportation Solutions already in Use\Pilot projects with municipalities	3	2	4
Innovative Transportation Solutions already in Use\On demand services	0	0	0
New Mobility			
New Mobility\Future Mobility			
Future Mobility\Improving innovative mobility services	0	2	0
Future Mobility\Integration of new mobility services into existing ones	0	2	3
Future Mobility\Limitations of non-MIT solutions	5	3	4
Future Mobility\Alternative drives	0	4	0
Future Mobility\Innovative mobility combined with housing	0	0	0
Future Mobility\Increased importance of cycling	0	0	0
Future Mobility\New pricing models for mobility providers	0	0	3
Future Mobility\Mobility as municipal service	5	2	0
Future Mobility\Non-profit, open source	0	4	2
Future Mobility\Users value intermodal routing	2	3	0
Future Mobility\Mobility niches with innovative means of transport	0	0	2
Future Mobility\Requirements for innovation projects	3	0	0
Future Mobility\Rather low mobility innovation	0	0	0
Future Mobility\Cooperation between transport companies	0	0	0
New Mobility\Sustainability Strategies			
Sustainability Strategies\Intermodal mobility platform for sustainable mobility	9	3	2
Sustainability Strategies\User-centricity of the mobility platform	11	2	2
Sustainability Strategies\Optimization with regard to ecological sustainability	3	0	0
Sustainability Strategies\MIT is explicitly disadvantaged	2	3	0
New Mobility\Long-term Mobility Transformation			
Long-term Mobility Transformation\Holistic transformation of the transportation system	0	0	7
Long-term Mobility Transformation\Social acceptance	0	8	5
Long-term Mobility Transformation\Long-term promotion of MIT alternatives	0	0	4
Long-term Mobility Transformation\Transformation to regional mobility providers	4	0	2
Long-term Mobility Transformation\Thinking mobility across Germany or Europe	4	0	2
Long-term Mobility Transformation\Demand-driven mobility solutions	0	0	0
Long-term Mobility Transformation\Fully sustainable mobility is virtually impossible	0	0	0
Long-term Mobility Transformation\Change towards centralization of transport associations	0	0	2
Long-term Mobility Transformation\Popularity of MIT does not change	0	0	0
Mobility Behavior			
Mobility Behavior\Current Mobility Behavior			
Current Mobility Behavior\Relevance of the car	5	10	9
Current Mobility Behavior\Comfort as the most important factor	0	0	0
Current Mobility Behavior\MIT more popular than public transport	2	10	2
Current Mobility Behavior\Aversions against public transport	2	5	2
Current Mobility Behavior\Special target group of innovative mobility	0	0	0
Current Mobility Behavior\General resentments	0	0	6
Current Mobility Behavior\Transfers as a barrier to transport	0	0	0
Current Mobility Behavior\Ecological sustainability an important for customers	0	0	0
Current Mobility Behavior\Individual transport attractive for first and last mile	0	0	2
Current Mobility Behavior\Popularity of the bicycle	0	0	3
Current Mobility Behavior\Mobility in non-public spaces	0	0	2
Current Mobility Behavior\Carpooling services are currently not used	0	0	0
Current Mobility Behavior\Differences between urban and rural areas	0	0	0
Mobility Behavior\Future Mobility Behavior			
Future Mobility Behavior\Expectation of free data	3	2	0
Future Mobility Behavior\Intermodality as a rival to the car	2	0	0
Future Mobility Behavior\Positive view of intermodality	2	3	0
Future Mobility Behavior\Mobility platforms for the best route	2	0	0
Mobility Behavior\Influences on Mode Choice			
Influences on Mode Choice\Perception of mobility costs	0	3	0
Influences on Mode Choice\Low visibility of public transport for MIT users	0	0	0
Mobility Behavior\Remote Work			
Remote Work\Reduced mobility through remote work	0	0	2
Remote Work\Shift in mobility through remote work	0	0	0
Mobility Planning and Needs			
Mobility Planning and Needs\Needs, Identification and Problems			
Needs, Identification and Problems\Key metrics for mobility needs	0	4	4
Needs, Identification and Problems\User mobility behavior is not tracked	5	16	4
Needs, Identification and Problems\User mobility behavior is tracked	0	0	0
Needs, Identification and Problems\Local data for traffic and transportation planning	2	5	6
Needs, Identification and Problems\Impulses for simulation	2	8	2
Needs, Identification and Problems\Low GTFS data for demand response planning	0	0	0
Needs, Identification and Problems\Funding models for public transportation not sustainable	0	0	5
Needs, Identification and Problems\Empty trips	2	0	2
Needs, Identification and Problems\Small-scale mobility solutions	3	2	2
Needs, Identification and Problems\Demand distribution unfavorable for planning	0	0	0
Needs, Identification and Problems\A shift to finer data access is needed	3	0	0
Needs, Identification and Problems\Simple code base	2	0	0
Needs, Identification and Problems\Lack of business and end user solutions	3	0	0
Needs, Identification and Problems\Large events as short term demand shocks	0	0	0
Needs, Identification and Problems\Competition within the industry	0	0	0
Needs, Identification and Problems\Non-public mobility space	3	0	0
Needs, Identification and Problems\Corporate social responsibility	0	0	0
Needs, Identification and Problems\Legal restrictions against individual motorized traffic	0	0	0
Needs, Identification and Problems\Planning Problems	0	0	0
Mobility Planning and Needs\Future Scenarios in Planning			
Future Scenarios in Planning\Mobility as a service scenario	15	8	2
Future Scenarios in Planning\Local mobility provider scenario	0	0	2
Future Scenarios in Planning\AI routing scenario	5	3	2
Future Scenarios in Planning\CO2 neutrality	0	0	0
Future Scenarios in Planning\Bundling mobility services through apps	0	0	0
Future Scenarios in Planning\US IT dominance scenario	2	3	0
Framework Conditions			
Framework Conditions\Economic Framework Conditions			
Economic Framework Conditions\Transport companies have their own business inter-ests	0	6	0
Economic Framework Conditions\Research collaborations	4	3	2
Economic Framework Conditions\Legal Basis	3	2	0
Economic Framework Conditions\Active data from transport associations	0	0	0
Economic Framework Conditions\Competition from US companies	2	3	0
Framework Conditions\Technical Framework Conditions			
Technical Framework Conditions\Insufficient data	6	8	0
Technical Framework Conditions\Insufficient infrastructure	8	3	0
Technical Framework Conditions\Algorithms are not powerful enough	8	6	0
Technical Framework Conditions\Insufficient data quality	0	10	2
Technical Framework Conditions\Technical risks / limitations of new forms of mobility	2	2	0
Technical Framework Conditions\Technical interfaces with existing infrastructure	0	3	0
Framework Conditions\Government Framework Conditions			
Government Framework Conditions\Budget for public transport too small	0	0	6
Government Framework Conditions\Decentralization of public transport	0	0	4
Government Framework Conditions\Public transportation as a service of general interest	0	0	0
Government Framework Conditions\Public authorities must act without discrimination	0	0	4
Government Framework Conditions\Tax measures / incentive policies	0	0	0
Government Framework Conditions\No legal framework for pivot data	6	3	0
Government Framework Conditions\Right to work from home influences mode choice	0	0	3
Government Framework Conditions\No awareness of open data in public administration	5	0	0
Government Framework Conditions\No operator structure for open-source products	0	0	0
Government Framework Conditions\Lengthy setup in other municipalities	0	0	0
Government Framework Conditions\Security as a framework condition of public space	3	0	0

Fig. 29. Code Relations Table for Framework Conditions.

Data availability

The data presented is available on request in anonymized form from the author due to privacy reasons (personal data of respondents included in the transcripts). The guide is available in the appendix.

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