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Understanding the relationship between experiences and choices under uncertainty: A stated choice experiment

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ABSTRACT

Complexity and uncertainty are fundamental in transition decision-making. These are however rarely used as lenses for studying innovations and transitions with a behavioral lens. Existing literature focuses on system-related uncertainty and complexity, rather than on how decision-makers themselves perceive uncertainty in complex projects. This paper aims to understand the direct relationship between decision-making conditions and choices made under uncertainty, using a hypothetical mobility innovation project. We designed a discrete choice experiment to identify what the most significant factors are for decision-makers when deciding ways forward, in line with theoretical answers to complexity focused on risk sharing, risk assessment, or risk avoidance. In total, 108 Dutch mobility professionals working on innovations were presented 8 scenarios, resulting in 848 observed choices. The final choices were estimated by a mixed logit panel model with error components. The key finding of this study is that decision-makers consider trust to be the most crucial factor in making strategic choices under uncertainty. The estimation of a long-term sustainability effect of an innovation did not significantly influence the decision to proceed with a mobility innovation project in our study. Therefore, translating long-term sustainability goals into concrete tasks and ensuring their implementation requires attention and warrants further research.

1. Introduction

One key aspect of transitions is their open-endedness and uncertainty about which innovations and pathways of interactions between niches, regimes, and landscape(s) will prevail (Geels and Schot, 2007; Köhler et al., 2019). These macro interactions are formed by decision-makers who struggle with the major long-term uncertainties when developing innovations. Here, we focus on that link in a transition based on innovations for a sustainable mobility system. A mobility innovation project gathers around a group of public and private actors who form a temporary collaborative network (Latour, 1996). Innovating a mobility system through projects is an activity in which public and private actors collaborate with major uncertainty about the future contributions of innovation within the dynamic system in the transition, and also what role each actor has to play in making it work (Author et al., 2023; Geels, 2012; Pel, 2022; Führer et al., 2025). How these uncertainty dynamics drives decision-making behaviour in transitions provides us with our research gap.

Recently, attention has been given to the role of actors' experiences and emotions towards transitions, highlighting the role of human dimensions and responses to innovations and technologies (Bogner et al., 2024; Martiskainen and Sovacool, 2021). With these, we argue that uncertainty is not just a system characteristic that can be measured or optimized. Instead, we define uncertainty as an *experience* of lack of knowledge to make decisions, related to emotions and feelings, and mediated through actions in organizations and institutional structures (Scoones and Stirling, 2020; Stanton and Roelich, 2021). Decision makers' experiences of uncertainty are the basis for many concrete choices in innovation and transition processes, such as excluding or including specific stakeholders, changing the project scope, taking an ecosystem approach, or appointing specific leaders (Braams et al., 2023; Gomes et al., 2019). Transitions depend on countless decisions made by policy makers, engineers, and managers. Each decision is shaped by how individuals perceive, frame, and cope with uncertainty (Von Wirth, 2025). The way uncertainty is managed by decision-makers can thus steer innovation processes and thereby transitions in specific

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directions (Loorbach, 2010). However, the transition research community often puts emphasis on successful and positive aspects of transitions, instead of focusing on uncertainties, let alone studying the way decision-makers handle these uncertainties (Turnheim and Sovacool, 2020 Malekpour et al., 2020; Lazarus and Funtowicz, 2023).

Therefore, this paper aims to better understand the relationship between the presence of different types of uncertainty at the actor level in the decision-making context and the consequent strategic choices they favor from their experience. This study makes concrete how uncertainty affects decision-making practices that can be framed as transition tasks (Braams et al., 2022). Having better insight into the role of uncertainty in decision-making processes enables one to anticipate better for potential problems in innovation projects, by intervening on individual and organizational competencies in dealing with uncertainty. This can provide an extension to transition management and strategic niche management approaches (Loorbach, 2010; Schot and Geels, 2008). The research question that this paper wants to answer is: How do different types of uncertainty structure decision-makers' strategic choices in a mobility innovation project? The hypothesis is that different responses as found in the literature relate to various forms of uncertainty, as experienced by the decision makers.

We have conducted a discrete choice experiment (DCE) in which 106 Dutch mobility professionals filled in their preference for an uncertainty management strategy in multiple innovation scenarios. In short, the experiment simulates a decision-making choice under uncertainty, and scrutinizes thereby the process of how an actor interprets an uncertain situation, and consequently decides what the best option to take given that situation. The scenarios describe an uncertain decision-making context, using multiple variables. The targeted respondents were Dutch mobility professionals who are working at public and/or private organizations in the Netherlands, and who have experience with developing and/or implementing mobility innovation projects. For the innovation scenarios, a combination of multiple uncertainties was included, on which basis respondents had to decide to continue together, do a risk estimation, or temporarily suspend the innovation project. These options found their basis in uncertainty responses in the wider literature on uncertainty, with collaborative, analytical, and psychological treating of risk approaches. More hybrid and phased approaches were excluded because of the limited set of options appropriate to a DCE. Respondents were asked to fill in the survey using their own intuition, rooted in their experiences, background, and knowledge of mobility innovations. In the innovation scenarios, no specific example of a mobility innovation was mentioned so that respondents would not be primed to one specific innovation. The application of a DCE in research on uncertainty and transitions allows linking decision-makers' preferences and choices regarding uncertainty into more generalizable preferences. In doing so, this research operationalizes the link between uncertainty being a system characteristic and uncertainty being an emotional and cognitive construct as interpreted by the decision-maker. Making this connection enables us to find tipping points where decision-makers choose to go from one uncertainty management strategy to another, and under which conditions this happens. The application of DCE in transition research can particularly generate more generic insights into behavioral decision-making patterns, in addition to, for example, QCA methodologies and other meta-analysis methodologies of case studies (Köhler et al., 2019). The paper presents a novel use of DCE through which it also provides an innovative perspective of the choice behaviour of decision-makers under uncertainty, bridging more synthetic and more empirical analyses of such behaviour.

The structure of the rest of this paper is as follows. Firstly, in 2 go deeper into the theoretical background of uncertainty types and handling strategies, relevant for transitions, which form the basis for the applied innovation scenarios in the choice experiment. Then, in 3 present the DCE design and how it has been presented to respondents. This also includes the setup of the survey, along with the operationalization of scenario variables. In section 4 present the research results, which will be discussed in 5, and the conclusions will be given in section 6.

Table 1
Categorizing uncertainty with illustrative examples for innovations.

	Short term	Long term
System	Technical feasibility	Changing sustainable travel behavior
Governance	Funding of an innovation project	Conflicts and trust between actors

2. Theoretical framework

2.1. An uncertainty typology for transitions

To build different innovation scenarios that include different types of uncertainties, we have reviewed literature about relevant categories of uncertainties. These categories are translated as scenario variables in the DCE survey. There are multiple categorizations of uncertainties described in the decision-making literature, based on different natures and objects of uncertainty (Dewulf and Biesbroek, 2018, Veenma et al., 2023; de de Vasconcelos Gomes and da da Silva Barros, 2022), or different levels of uncertainty (Author 2019), or on their source and location (Kwakkel et al., 2010;). We categorize based on two aspects of uncertainty: the type of uncertainty regarding its object (What aspect of the innovation is uncertain?), and the timeframe of the uncertainty (Is the uncertainty about a short-term or long-term issue?). This conceptualization has been displayed in Table 1 and is rooted in existing empirical studies (Author et al., 2023; Authors 2024) that build upon earlier-mentioned sources. We will now elaborate on each of the aspects.

Firstly, we make an intuitive distinction between *system* and *governance* uncertainties. System uncertainties are about the (technological) innovation itself and its future functioning in the mobility system regarding user uptake and system change. Transitions are open-ended because it is uncertain which innovation will be dominant in the future, given the dynamics (Geels, 2012). Governance uncertainties are about actor dynamics and the structuring of the decision-making process for developing and implementing innovations. This relates to questions of how to govern, experiment, and intervene in systems with multiple actors (Loorbach, 2010). By a case study comparison of Mobility as a Service and rail innovations, we found that actors experience predominantly uncertainties about governance issues such as agreements, accountability, and legitimacy of funding, rather than system uncertainties about the functioning of the innovation in a future system (Author et al., 2023). Other studies have observed the coexistence of both types of uncertainty, such as Meijer and Hekkert (2007), who conclude that technological and political uncertainties were equally important in Dutch innovation cases. Bornemann et al. (2016) conclude that for Swiss energy planning, technological and economic uncertainties are more important than societal and political uncertainties. However, for a mobility context, it can still be expected that governance uncertainties are more important for decision-makers than system uncertainties, given the highly institutionalized and regulated context of public-private interactions (Hirschhorn et al., 2020).

Secondly, we make a distinction between short-term and long-term uncertainties. Although there is a normative debate about the desirability of distinguishing short-term and long-term issues (MacKenzie, 2021), we find that this distinction is relevant to understanding empirical practices of decision-making. In transition literature, the temporal dimension of uncertainty relates to questions of how to achieve long-term change through short-term steps in transitions (Kemp et al., 2007) or how to balance short-term practices with desirable long-term futures (Sondeijker et al., 2006). In practice, there can also be opposition between actors who demand short-term results versus the actors

that care for long-term values and corresponding actions (Avelino, 2009). There is a difference between second-order goals of transition management in the form of sustainable change and learning, and the daily practice of decision-making in the form of project management and choices that managers face (Bruijne et al., 2010). Through comparative case study research of four mobility innovation trials, we found that decision-makers were mainly concerned with short-term uncertainties, rather than long-term uncertainties (Authors 2024). For example, in the trials, questions about how to develop a sustainable business model were not on the table. It is not that there were no uncertainties about long-term issues (e.g., the governance between public and private actors), but such uncertainties were not experienced as problematic by actors, given the limited project scope.

To summarize, four aspects of uncertainties (short-term system, long-term system, short-term governance, long-term governance) form a two-by-two matrix, displayed in Table 1. This table has formed the conceptual basis for the innovation scenarios in the survey that have been presented to decision-makers in the mobility field. Illustrations are given in the table. The technical feasibility of an innovation can be categorized as a short-term system uncertainty, as it is about the basic technical functionality of an innovation in a controlled and protected experimental setting (Smith and Raven, 2012). Such technical project aspects can include making a mobility app work in practice, using an API and a user-friendly interface without crashes and other errors, or the coupling of energy infrastructure in electric charging of vehicles. Organizing funding for an innovation project is a short-term governance uncertainty, as it is about agreements between actors given a limited project scope. Project funding includes uncertainties about which actor pays how much, and questions about accountability and distribution of costs when the innovation project is more expensive than expected. Conflicts and trust between actors can be categorized as a long-term governance uncertainty, as institutional collaboration patterns between public and private actors stretch over a longer period beyond an individual project scope (Chen et al., 2014). It can relate to, for example, the institutional embedding of a start-up in an existing mobility regime, and the issue of alignment between these two (Pelzer et al., 2019). Finally, changing travel behavior is a long-term system uncertainty, as it is about the effect of the innovation on sustainable travel behavior in a given system, beyond the scope of an individual project. Although many innovations have the aim of making the mobility system more sustainable, it is hard to predict and measure when an innovation has a real impact in the long-run.

2.2. Handling uncertainty: two possible strategies

Decision-makers adopt different strategies to deal with uncertainty, given their individual preferences and institutional background (Author, Under review; Dewulf and Biesbroek, 2018; Haas et al., 2023; Aarninkhof-Kamphuis et al., 2024). In the DCE survey, these strategies will be translated into different alternatives that respondents can choose as a response to the uncertainties as presented in the innovation scenarios. Based on the literature, we examine decision-makers' preferences to choose either a collaborative approach to deal with uncertainty or an individual approach. Through earlier case study work, we find a difference between experimental approaches and classic project management approaches (Author et al., 2023). Secondly, a difference is described in the literature between individual strategies and concerted strategies (Klijn and Koppenjan, 2016). Individual strategies aim to maximize one's own benefits, while concerted strategies seek to address the uncertainties through coordination with others (Dewulf and Biesbroek, 2018). We have translated these handling strategies into two choices regarding the uncertainties presented in the innovation scenarios. The first choice is a project management approach that sees uncertainty as risk and involves a reducing strategy, by trying to decrease the risk for the individual organization. The second choice is going for an experimental approach that focuses on collaboration, in which reflection and embracing of uncertainty with others is key (Ansell and Gash, 2008; Dolmans et al., 2023; Zandvoort et al., 2019). Based on our earlier work (Author et al., 2023), we hypothesize that respondents choose a risk approach over a collaborative approach when there are more uncertainties included in the innovation scenarios.

3. Methodology

A survey was set up based on the conceptual framework of four categories of uncertainty, as well as the two distinct handling strategies to deal with uncertainty, to gain insight into the relationship between choices under uncertainty and the conditions of an innovation project. The survey includes a choice experiment, questions on attitudes towards uncertainty, organizational, and personal statements.

3.1. Discrete choice experiment

DCEs have a theoretical basis in random utility theory (McFadden, 1974). It is a quantitative research method with the aim of building a mathematical model that explains how individuals make choices. This model is fed by empirical data about hypothetical or stated preferences of respondents about choices between two or more alternatives, in contrast with revealed preferences about past choices in the real world (Hensher 1993). These alternatives are described by multiple attributes, and in a DCE, respondents make choices based on the different levels of attributes in that choice set (Louviere et al., 2000). The underlying assumption of the mathematical model is that individuals choose to maximize the alternative with the maximum utility, given the different attributes and attribute levels for each alternative. A model can be estimated based on responses from a DCE. Setting up a stated choice experiment consists of different steps: Selecting attributes to include in the scenarios, determining the relevant attribute levels, selecting a method for combining the attribute levels into scenarios or profiles, and choosing the set of alternatives. Then, a method for estimating the utility function should be chosen so that the preferences based on the utility functions can be simulated. All these steps are described in Sections 3.2 – 3.5. In our DCE, we do not vary attribute levels, but instead we use context or scenario variables. This means that we have set up a context-dependent stated choice experiment, rather than a standard DCE (Molin and Timmermans, 2010). Because attributes are bundled within predefined scenarios, estimated effects should be interpreted as reflecting respondents' preferences over holistic contexts rather than marginal trade-offs between independently varying attribute levels. The use of labeled contextual scenarios enhances realism and cognitive validity, which is a primary motivation for the chosen design given the complexity of decision-to-be-made.

DCE has been widely applied to study consumer choices in marketing, (environmental) economics, and the mobility domain. Also, it has been used to study decision-maker choices in the health context, for example, in the context of doctors' decisions (Muhlbacher and Juhnke, 2013). The application of DCEs in the context of decision-making for sustainable innovations is quite rare, though. Some studies have looked at policymakers' preference for technology to decarbonize mobility (Bjørnåvold et al., 2020), decision makers' preference for innovation strategies to e.g. collaborate with other companies (van Rijnsoever et al., 2017, 2012), or subsidiary managers' decisions to pursue initiatives for innovative product introductions (Ambos et al., 2023). We have found some studies that explicitly incorporated uncertainty into a choice experiment, but only in the form of an attribute that described different alternatives. For example, Davies et al. (2023) have studied how different likelihoods of reduction in deaths and flood risks affected the choice to go for different ecosystem service programs. Another study also included uncertainty as a labelled attribute by "the probability that a policy will be effective" (Lundhede et al., 2015). Faccioli et al. (2018) distinguished a certain and uncertain treatment in its attribute levels, where a probability was added to the uncertain treatment. However, according to the authors' knowledge, no study included a stated choice experiment in

which the respondent had to make strategic choices based on scenarios consisting of variables that represent uncertainties in the decision-making process. We thereby not only use a qualitative research method to design our choice experiment (Kløjgaard et al., 2012), but also use the stated choice experiment as a research methodology to generalize and validate research findings from qualitative research.

3.2. Data collection

The aimed respondents of the survey were Dutch stakeholders in the mobility field (both public and private), who are or were working on innovations in the mobility and infrastructural domain. This study sample corresponded with the studied actors in earlier qualitative work (Author et al., 2023; Authors 2024) and could be reached via our personal network. The survey was online distributed via Qualtrics, and respondents were gathered via LinkedIn and direct e-mailing through personal connections in the mobility field. Also, respondents were asked to distribute the survey in their organization. Data collection took place between March and April 2024, and one reminder round was sent via email to the list of personal connections.

3.3. Study design

Based on the theoretical framework, we have translated and operationalized the four categories of uncertainties in Table 1 as scenario variables with corresponding levels for the choice experiment, according to design steps as described in the literature (Rose and Bliemer, 2014). The variable levels have been labeled, instead of using percentages of e.g., 20% or 60% to incorporate uncertainty in the experiment. Such percentages would do no justice to the qualitative empirical basis of this paper. Also, we did not see reason to go beyond binary uncertainty levels (in a labelled way), because we did not know whether respondents would understand our experimental design in the first place. Initial designs of the choice experiment that included unlabeled variable levels were tested with around ten persons, and these tests confirmed that respondents were struggling with the meaning of such numbers for a hypothetical innovation scenario. A more complex set-up of variable levels would require the application of additional methods to generate fractional factorial designs, and a simpler set-up was easier to construct, obtain, and interpret in line with the exploratory nature of the overall experiment (Rose and Bliemer, 2009). In the statistical analysis, the labeled variable levels are represented by dummies in the form of low uncertainty (0) and high uncertainty (1). An overview of the included scenario variables and levels is displayed in Table 2.

3.4. Choice scenarios and survey

The respondents were introduced in the survey with the following text:

"In this survey, eight different scenarios regarding a mobility innovation project will be presented to you. Imagine for these scenarios that you have the responsibility to successfully develop this innovation. The entire project team consists of a government, an experienced contractor, and a start-up. Have a good look at the scenario. Then, we ask you, as a mobility professional, what you think is the best approach, based on your own experience, background, and organization. You can choose only one option, so select the one that best aligns with your advice."

For the experimental design, we assumed that respondents would make choices based on their own background and experience with mobility innovations. In earlier versions of the survey, we assigned respondents the role of project manager, but after initial testing, respondents wondered whether this project manager was hired by a consultant or the government. The choice was made to let respondents fill out the survey by relying on their own background, and to ask about that background after the choice scenarios. Another design choice was the question of whether to show respondents a specific innovation or scenario based on innovations such as Mobility as a Service (MaaS), autonomous vehicles, or another innovation that is currently being developed in practice. We chose not to mention a specific innovation, as mentioning an innovation such as an autonomous vehicle could incite respondents' specific expectations (Graf and Sonnberger, 2020), instead of weighing specific attributes and strategies regarding uncertainty. After the choice tasks, we asked the respondents though if they had any specific innovation in mind when answering the choice tasks.

Based on the specified attributes and corresponding attribute levels as displayed in Table 2, we have chosen to do a full factorial design by a basic orthogonal design of attributes, since the permutation of all attribute levels would only result in eight unique profiles. Because a full factorial design with two-level attributes is inherently orthogonal, this approach allowed us to construct eight choice sets without the need for fractional design techniques. The limited number of levels of the attributes allowed for complete coverage of the attribute space. The focus of our study lies on estimating main effects, not higher-order interaction effects. We opted for a respondent-friendly approach with fewer choice sets, given the expectation that the tasks would already be quite complex to handle by the respondents.

The choice set consisted of three alternatives: Propose to suspend the project, do a risk estimation, or explore together as a consortium. Also here, different forms of alternatives were assessed with respondents, such as limiting the choice to "go" or "no go" or giving even more alternatives, such as "checking contracts" or "set up an adaptive strategy". Eventually, the choice was made to stick to the theoretical framework, and test in which circumstances respondents would do a risk estimation (focused internally, for their own organization), or explore together how the innovation can be made working (focused externally, based on collaboration). A third "suspend" option was added as an alternative to stop the innovation project. An example choice task for respondents is displayed in Figure 1.

The main part of the survey consisted of working through the scenarios and the corresponding choice tasks. Also, for each scenario,

Table 2
Included variables and levels in the context scenarios.

Scenario variable	Operationalization	Levels	Representing
SSU (System Short-term Uncertainty)	Technology of innovation	The technology is available and has been tested abroad	0 (Low uncertainty)
		The basic technology is available, but it has not been used or tested anywhere	1 (High uncertainty)
SLU (System Long-term Uncertainty)	Estimation long-term sustainability effect	Models expect a positive effect on sustainable travel behavior	0 (Low uncertainty)
		Models are not clear at all about the effect on sustainable travel behavior	1 (High uncertainty)
GSU (Governance Short-term Uncertainty)	The financial situation	There is sufficient and guaranteed budget	0 (Low uncertainty)
		There are big gaps in the budget that have not been covered	1 (High uncertainty)
GLU (Governance Long-term Uncertainty)	The collaboration process	All actors know each other, and there is trust	0 (Low uncertainty)
		Previous conflicts have compromised trust in each other	1 (High uncertainty)

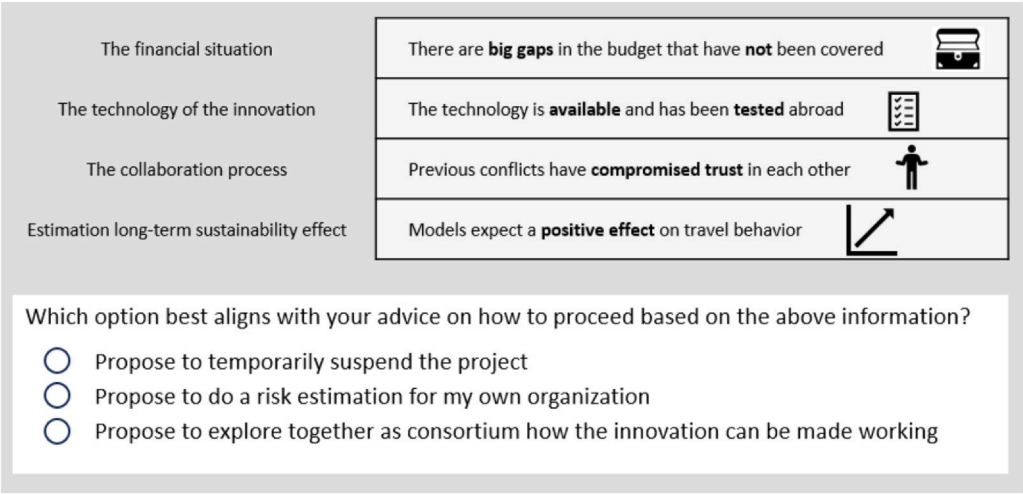

Fig. 1. Example of one choice task.

respondents were asked how uncertain they estimated the success of the project (5-point Likert scale: Very uncertain – very certain). After the discrete choice experiment itself, the respondents were asked whether they had missed any element, consideration, or action in the scenarios and alternatives. Also, they were asked if they had any mobility innovation in mind when evaluating the scenarios. The final part of the survey concluded with some general questions about the background of the respondent (employer, age, work experience with mobility innovations), and questions to measure the individual and organizational level of innovativeness.

3.5. Statistical and qualitative analysis

The DCE contained three dependent variables for each choice set (i.e., suspend, do a risk estimation, or explore together), and each choice was considered one observation in the choice set. We chose to analyze the observations by a mixed logit model for panel data with error components (Train, 2003). We also tested alternative model specifications (standard multinomial logit (MNL), and a Mixed Logit model without error components). Across all specifications, the sign and significance of the coefficients remained stable, which supports the robustness of our core findings. Yet, the panel model resulted in the best fit, given our data. A panel model takes into account that choices by an individual are correlated with other choices, because of a (partial) stability of preferences within the individual. See Bliemer and Rose (2010) for more theoretical background about mixed logit models that include panel effects. The error component captures unobserved individual-specific effects that are constant across repeated choice situations, thereby allowing for correlation across panel observations. This is particularly relevant in our setting, where each respondent makes multiple choices and latent factors such as attitudes or stable preferences may persist across choice tasks. The statistical significance of the error component variance indicates the presence of unobserved heterogeneity at the individual level beyond that captured by observed covariates. All main-effect coefficients were thus treated as fixed parameters, and a single error component was added to the model specification. Effectively, this makes our model an Error Component Logit (ECL) specification.

This error component can be estimated by making one thousand pseudo-random Halton draws from a normal distribution. We estimated the panel mixed logit model using the Software package of Appollo in R (Hess and Palma, 2019).

The following final specifications of the utility functions were used:

$$V_{risk\_estimation} = ASC_{risk} + \beta_1 SSU + \beta_2 SLU + \beta_3 GSU + \beta_4 GLU + \varepsilon_{joint}$$

$$V_{explore\_together} = ASC_{explore} + \beta_5 SSU + \beta_6 SLU + \beta_7 GSU + \beta_8 GLU + \varepsilon_{joint}$$

$$V_{suspend} = 0$$

where

V represents the systematic utility that a respondent has for a strategy to deal with uncertainty, given the innovation scenario

ASC represents the alternative specific constants for a strategy to deal with uncertainty, and suspend is the reference level

β_{1-8} represent parameter weights or coefficient values for each variable level

SSU, SLU, GSU, GLU represent the variable levels, SSU = System Short-term Uncertainty SLU = System Long-term Uncertainty, GSU = Governance Short-term Uncertainty, GLU = Governance Long-term Uncertainty

ε_{joint} represent the common error component for both alternatives.

The most important output of the model calculations is the parameter estimates and corresponding significance (p-value < 0.05). Also, the significance of the parameter indicates whether a scenario variable has a positive or negative effect on the stated alternative. Before the analysis, we expected to see negative signs for all scenario variables. We also expected that the governance variables would be more important than the system variables in choosing strategies to deal with the innovation scenarios, and that the short-term variables would be more important than the long-term variables. Also, we expected to see a shift from exploring approaches to risk management approaches to stopping the project, given the total level of uncertainty in the scenario.

Based on the estimated model, we calculated choice probabilities for each of the alternatives based on the estimated coefficients, to translate the rather abstract numbers to tangible scenarios and choices for practitioners. The choice probability P_j for choosing the option j is expressed as a fraction of the utility V_j of alternative j divided by the sum of utilities of all alternatives J summarized in the following formula:

$$P_j = \frac{\exp^{V_j}}{\sum_{j=1..J} \exp^{V_j}}$$

Finally, we analyzed whether there were interaction effects between background variables, individual and organizational variables, and the scenario variables. We also compared the respondents' experience of uncertainty (using the respondents' uncertainty score for each scenario) with the actual level of uncertainty of the scenario and set up a simple regression model with the experienced uncertainty score as the dependent variable.

Table 3
Overview of sample respondents (N = 106).

Socio-demographic and background variables	Percentage
Age group (years)	
18–29	4,7
30–39	24,5
40–49	27,4
50–59	30,2
59–70 +	13,2
Type of employer	
Government (Ministry, Province, Municipality)	34,0
Governmental Infrastructure Operators (Road and Rail)	21,7
Commercial Business (consultant, constructor, industry)	17,0
Traditional Transport Operator (rail, bus, metro/tram)	10,4
Start-up/Scale-up	4,7
Other	2,8
Type of contract	
Permanent contract	85,8
Temporary contract	0,9
Freelance	2,8
Own company	6,6
Detached	3,8
Type of work activities	
Strategic	49,1
Technical	15,1
Operational	3,8
Research	14,2
Networking	13,2
Other	4,7
Work experience with mobility innovations	
< 2 years	8,5
3 – 5 years	17,9
6 – 10 years	30,2
11 – 15 years	14,2
16 – 20 years	5,7
> 20 years	23,6

4. Results

4.1. Sample respondents

In total, there were 151 respondents, of whom 106 (total sample size) have fully completed the survey. Respondents had a mean age of 46 years (SD = 11). Respondents had a diverse background in terms of employer, although the majority had a career background in the government. There was a broad range of work experience with mobility innovations. Respondents categorized their work mostly as strategic and had a tenured contract. An overview of the respondents' characteristics can be found in Table 3.

Furthermore, we also measured respondents' individual and organizational level of innovativeness via nine attitudinal statements, including the extent to which their job was either societally or commercially focused. These results are displayed in Appendix A. In general, we found that sample respondents see themselves as highly innovative. No significant difference was found between respondents from different employers, such as the government or a consultancy. Using factor analysis, factor scores regarding the organizational statements have been saved as a variable given the sufficient Cronbach's alpha score, which were input for testing interaction effects in the choice model.

4.2. Discrete choice model

The results of the model estimation are displayed in Table 4. We have checked for multicollinearity, and there were very low correlations (< 0.6) between variables. All VIFs (Variance Inflation Factor) were below 2. As for the model, the factor regarding the estimation of the long-term sustainability effect of innovations does not significantly influence the respondents' choice to do a risk estimation or explore together (p = 0.27 and p = 0.17, respectively). The remainder of the scenario variables regarding technology of innovation, financial situation, and trust in the collaboration process do significantly influence the choice to do a risk estimation or explore together negatively, as expected. There is thus a negative effect of uncertainty on the choice of doing a risk estimation or exploring together. Moreover, this effect is stronger for exploring together than for doing a risk estimation. The largest effect on respondents' choice of strategies comes from the variable about the collaboration process, in the form of a trustful coalition between the innovation partners. The effect of the technology of the innovation is the second largest, followed by the financial situation regarding the innovation. The scenario variables regarding governance factors have a stronger effect on decision-makers' strategies to deal with uncertainty than the attributes regarding system factors. The scenario variables regarding long-term factors have a weaker effect on decision-makers' strategies to deal with uncertainty than short-term factors.

The ACS values indicate that respondents have a higher preference for explore together (parameter value of 4.676) than for risk estimation (2.506). Also, the relatively high value of these ASCs in comparison with the other variables means that there is a high contribution of unobserved factors for decision-makers' choices of strategies that is not captured by the scenario variables. In other words, there are important factors that have influenced the choice to explore together or do a risk estimation, other than the ones presented in the innovation scenarios. We will come back to this finding in the discussion by analyzing the answers to the open questions through qualitative analysis.

We have tested for interaction effects of individual and organizational variables (heterogeneity test). We found that respondents having a job with a larger focus on commercial benefits did have a significant interaction effect ($p < 0.01$) on the variable GLU to explore together. This means that respondents with more commercial jobs were less inclined to explore the innovation project together when there is a lack of trust between the stakeholders. The rest of the background variables regarding organizational attitude towards innovations, age, work experience with mobility innovations, and employer did not show significant interaction effects when directly included in the model specification.

Apart from the choice tasks, we also asked respondents per innovation scenario, their estimation of how successful the innovation would be, ranging from very uncertain to very certain. Such an analysis can show more insight in the relationship between the perception of uncertainty of each innovation scenario, and the actual levels of uncertainty present in the innovation scenario. A regression analysis (See Table 5) shows comparable results as the choice model outcomes, namely that the factor regarding the estimation of long-term sustainability effect of innovations does not significantly influence respondents' experience of uncertainty. For the rest of the factors, the collaboration process in the form of a trustworthy coalition between the innovation partners has the largest effect on the respondents' estimate of the success rate. Also here, a relatively high constant can be observed, which means that there are other unobserved variables relevant that explain the respondents' estimation of the chance of success.

Based on the utility function specification and model estimations, choice probabilities could be estimated for the decision-makers' strategies to deal with uncertainty. This resulted in $2^4 = 16$ (Two uncertainty levels, four variables) scenarios for which the choice probabilities have been calculated, displayed in Figure 2. The scenarios run from no uncertainty for all four scenario variables (Left, zero levels of uncertainty), till all scenarios present for the four scenario variables (Right, four levels of uncertainty), and all possible combinations of scenario variables in between. The scenarios including system, governance, short term, and long-term uncertainties respectively have been displayed separately.

The display of choice probabilities shows a clear pattern of diminishing support to explore together, as uncertainty levels in the innovation scenarios increase. As the coefficients for the variables already indicated, there is a high preference among respondents to explore together. For example, in the scenario where three types of uncertainty are present except for the trust in the collaboration process, 55% of respondents choose to explore together, 30% chooses to do a risk

Table 4
The effect of uncertainties in innovation scenarios on decision-makers' strategies based on a mixed logit panel model with error components (N = 106).

Parameters	MLEC panel model		
	Estimate	Standard error	p-value
Alternative Specific Constants (ASC)			
Suspend (reference level)	0		
Risk estimation	2.506	0.774	0.00
Explore together	4.676	0.743	0.00
Scenario variables Risk estimation			
SSU[a] (Technology of innovation)	-1.527	0.413	0.00
SLU[b] (Estimation of long-term sustainability effect)	0.269	0.246	0.27
GSU[c] (The financial situation)	-1.268	0.415	0.00
GLU[d] (The collaboration process)	-1.978	0.416	0.00
Scenario variables Explore together			
SSU (Technology of innovation)	-2.412	0.398	0.00
SLU (Estimation long-term sustainability effect)	0.323	0.237	0.17
GSU (The financial situation)	-1.995	0.398	0.00
GLU (The collaboration process)	-3.451	0.402	0.00
Common Error Component	0.754	0.146	0.00
Number of observations	848		
Null-Likelihood	-938		
Final Likelihood	-737		
Likelihood Ratio Test (LR)	402		
Rho Squared	0.208		
AIC	1497		
BIC	1550		

[a] System Short-term Uncertainty,
[b] System Long-term Uncertainty,
[c] Governance Short-term Uncertainty,
[d] Governance Long-term Uncertainty.

Table 5
Regression analysis of experienced uncertainty and actual levels of uncertainty in innovation scenarios.

Dependent variable: Estimation of the chance of success		
Variables	**Beta coefficient**	**p-value**
Constant	4.006	0.00
SSU[a] (Technology of innovation)	-0.948	0.00
SLU[b] (Estimation long-term sustainability effect)	0.026	0.72
GSU[c] (The financial situation)	-0.925	0.00
GLU[d] (The collaboration process)	-1.382	0.00
R^2	0.513	
Adjusted R^2	0.511	

[a] System Short-term Uncertainty,
[b] System Long-term Uncertainty,
[c] Governance Short-term Uncertainty,
[d] Governance Long-term Uncertainty.

estimation, and only 15% chooses to suspend the innovation project. However, when a scenario does include a lack of trust between innovation partners, respondents very quickly move to doing a risk estimation or suspend the innovation project all together. The slight drop of suspend choice when moving from the 15th to 16th scenario where all uncertainties are included can be explained by the (not significant) positive coefficient of the variable for estimation of long-term sustainability effect. When looking at the scenario that included either system uncertainties or governance uncertainties, we find that for governance uncertainties respondents are almost split between the three strategies (33%), whereas with system uncertainties the large majority choses to explore together (77%). There is a similar pattern for either long-term or short-term uncertainties in the innovation scenarios, but respondents choose to explore together more when only long-term uncertainties are included (64%) instead of short-term uncertainties (51%).

4.3. Qualitative analysis of open questions

We have coded the answers given to the question whether respondents had missed any elements, considerations, or actions in the choice tasks. Seventy-five out of 106 respondents have given an answer to this question, which resulted in one hundred unique excerpts. These excerpts have been cross-compared and categorized in two codes about methodology and making a choice in general, and seven codes about the content of the choice scenarios (See Figure 3).

The elements most missed in the choice scenarios were about collaboration and trust between stakeholders. Respondents mentioned that there is a difference between individuals as part of a core team who do not trust each other, and organizations that do not trust each other. In case of multiple organizations, it matters when there is one or two smaller organizations that resist, instead of the leading stakeholder. Also, it matters whether another stakeholder can replace a distrusting organization. The second most important was the public and political support for the innovation. Respondents mention that political will is both an enabler and a necessary condition for letting the innovation succeed. A respondent mentions: “An innovation can be effective, work well, and the consortium can have a good time, as long as there is no political support, the innovation makes no sense.” A third important missed element was the organizational willingness to take risks and to invest in an innovation, given the uncertainties. If there is more potential, respondents indicate, there might be more willingness to go through with the innovation. Less mentioned elements were about the budgetary situation (return on investment, financial backing by stakeholders), the goal of the innovation trajectory (learning, or direct operational application), and the technology and models (models are not reliable, and technology always has to be tested in the follow-up phase). Respondents’ answers to these last categories explain why the estimation of long-term sustainability effect through models was not important as a variable in the choice model. Respondents mention, for example, that effectiveness regarding sustainable mobility is not an issue, because the goal of the pilot is exactly to learn: “If the effect is disappointing, bad luck”. Also, models are not experienced as reliable to predict travel behavior, so real tests have to be done according to respondents.

Regarding the methodology and choice experiment itself, some respondents mention that they found it hard to choose because they did not know from which perspective they would answer the survey (e.g., a government, supplier, or start-up). Also, respondents say that context was missing about the phase the innovation is in, and what the

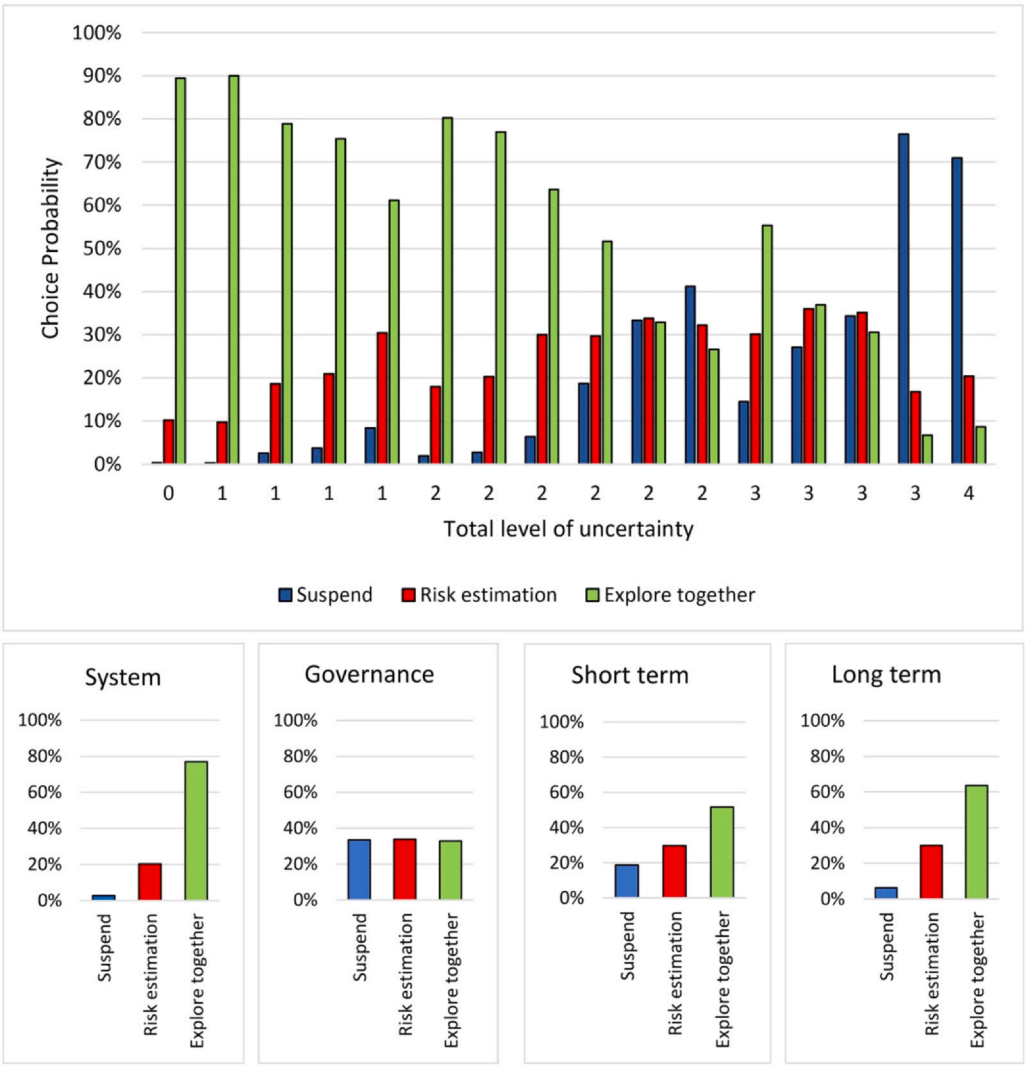

Fig. 2. Choice probabilities for decision-makers' strategies to deal with uncertainty, for the total level of uncertainty in innovation scenarios (top), and for system, governance, short-term, and long-term uncertainties respectively (below).

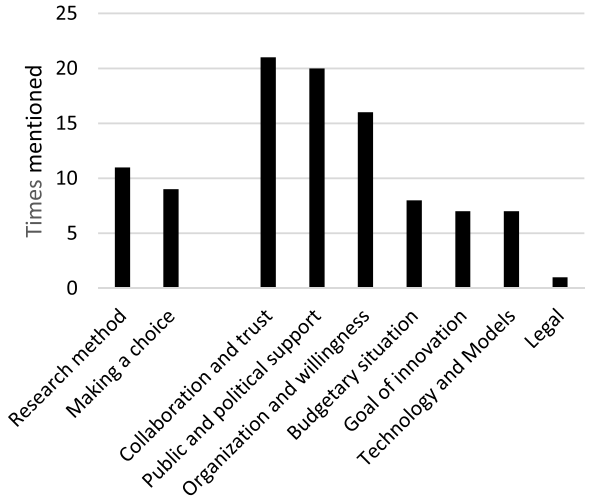

Fig. 3. Codes based on qualitative analysis about missing elements in choice tasks.

definition of 'success' means. Finally, respondents found it hard to choose between the three choice options. They indicate, for example, that they would have liked to choose to start small, and then scale up, or continue for now and postpone the decision to stop, do more research, or set go/no go moments with criteria to contain risks. Also, some respondents missed a question about sentiments and gut feelings, which can be the basis for making decisions under uncertainty.

We also asked which mobility innovations respondents had in mind when answering the choice tasks (displayed in Figure 4). We found that most innovations were highly centered around public and private collaboration, such as shared mobility, MaaS, and mobility hubs. To a lesser extent, technological innovations were mentioned, such as autonomous vehicles and the hyperloop/maglev.

5. Discussion

This paper presented the outcomes of a DCE study that looked into the relationship between uncertainty present in innovation scenarios and decision-makers' choices. The survey was filled in by 106 Dutch respondents, all working on mobility innovations for either a public or private organization. We relied on convenience sampling, which might have resulted in a potential bias in the results. However, given the small population of mobility innovators in the Netherlands, we do think we have sampled a representative share of the total population. Also, the purpose of this experiment was not to represent the full share of Dutch mobility professionals but to provide the first evidence of behavioral patterns based on more than 800 choices made in the experiment. The

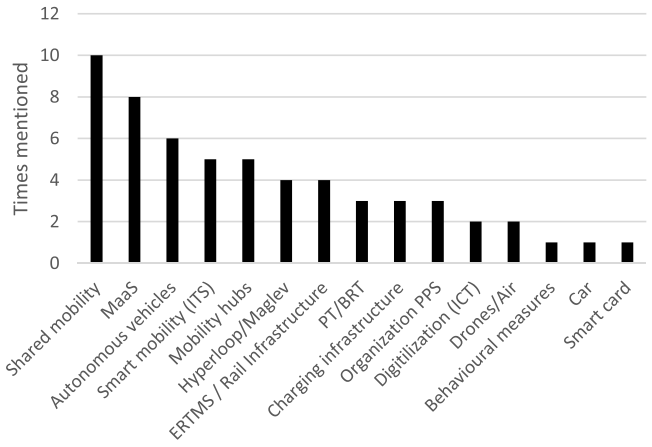

Fig. 4. Respondents' mobility innovations in mind when answering the choice tasks.

results of the choice experiment, in combination with the results of the qualitative analysis of open answers, can be interpreted in the following way.

Firstly, respondents have a high preference for exploring the innovation together, even when there are many uncertainties present in the innovation scenario. This can be explained by the fact that all respondents regard themselves as innovation-minded, which means that they accept quite high levels of uncertainty in innovation scenarios. The most important scenario variable influencing the choice to explore together or do a risk estimation is uncertainty about the trust and collaboration process between actors, being around 30% more important than the availability of proven and tested technology and 70% more important than the financial situation of the innovation process in terms of funding. The estimation of a long-term sustainability effect did not significantly influence the respondents' choice to move forward or not with the innovation process. These results confirm the results of earlier qualitative case studies on mobility innovations (Author et al., 2023; Authors 2024), where it was found that uncertainty about long-term sustainability questions was not experienced as an issue.

The relatively high value of the alternative specific constants given the effect of the attributes also indicated that there were important factors that have influenced the choice to explore together or do a risk estimation, other than the ones presented in the innovation scenarios. This interpretation of data is reinforced by the adequate but not strong Rho squared value of 0.208. This value indicates namely that the model captures the main preference structure, but that not all choice variation is explained by the model. When analysing why this is the case, the results of the open questions regarding missing elements in the scenarios can help. We found that governance issues regarding collaboration and trust, political and societal support, and organizational willingness were most mentioned by respondents. These results underline the finding that governance uncertainties are most important in making decisions under conditions of uncertainty, as respondents indicate that they mostly missed governance uncertainties instead of system uncertainties in the choice scenarios. Also, the qualitative answers provide a first answer to why the estimation of the long-term sustainability effect is not considered to be relevant, as respondents mention that the goal of the innovation is to learn and explore. Uncertainty about the sustainability effects of the innovation seems to be expected by respondents and is therefore not an issue when making a choice to continue with the innovation process or not. However, nuance should be added to this statement, based on the respondents' indications about the missing context of the phasing of the innovation when answering the questions. It could be the case that at the start of the innovation process, a sustainability criterion is less important, but when this criterion will not be met in the long run, decision-makers still stop working on the innovation. Theoretically, this could mean that there is a shift in prioritization of uncertainties throughout the innovation project, dependent on the state of the innovation and the corresponding collaboration process.

The limited context we gave the respondents when answering the choice tasks is one of the largest limitations of this research. Adding more context on political support and leadership, background information about the collaboration partners, and the innovation itself can be explored and tested in other experiments. This could also include a differentiation between technical innovations and more organizational innovations. Other limitations relate to the relatively small sample size, which limits the generalizability of our study. Also, the survey measures choices on an individual level, whereas many innovation processes are a collective process of making decisions (Ansell and Gash, 2008). When, for example, four out of five decision-makers want to continue with the innovation, it might mean in practice that the innovation project will not continue because consensus has not been reached. The survey asked to make hypothetical choices, which might mean that it is relatively easy to pick the choice to explore together since there are no (real-life) consequences at stake. The sample is very innovation-minded, and this is reflected in the low choice probabilities to suspend the innovation project and high probabilities to explore together. Although we wanted to aim for respondents who had work experience with mobility innovations, the relatively low heterogeneity of respondents in the sample and small sample size make it harder to estimate interaction effects. Also, with a more heterogeneous sample, it would have been interesting to see whether less innovation-minded respondents would have chosen the same, given the scenarios. For example, you could expect in practice that there are many bystanders around innovation projects that have to make decisions for that project (e.g., legal staff, asset managers), but who are not directly involved in the innovation project itself.

Methodologically speaking, there were also some limitations related to the chosen choice model and applied statistical methods, including:

- The contextual focus of the experiment
- The initial uncertainty experienced by the respondents
- The unknown consequences of a decision on other decisions

The choice to perform a context-dependent experiment limits the generalizability of the exact numbers of this study, given another study sample. However, there is a trade-off between external validity (generalizability) and internal validity (increased realism of the choice tasks). In this case, we chose internal validity over external validity.

In addition, the experience of uncertainty in the decision process needs to be researched. The uncertainty currently represented by words and scenarios in this stated choice experiment could become more tangible and meaningful for respondents by for example setting up a VR-setting in which respondents have to make choices to either suspend the project or collaborate, given the context of multiple avatars negotiating in a group setting (Mokas et al., 2021).

This setup enables studyingthe consequences of a decision on other decisions. Future research could therefore also investigate including a phasing of the innovation process. When a phasing would be included in the choice tasks, decision-making paths can be explored per individual, given earlier made choices, and the changing circumstances (Haasnoot et al., 2013). Such a phasing of the innovation trajectory enables exploring different choice options, such as scaling up the experiment given the potential there is. Other variables worth exploring in future discrete choice experiments could be about potential innovation outcomes, organizational willingness to invest in the relationship between actors, and differentiating between the core team of project innovators and the broader range of employees internally and externally who are (not) willing to support the innovation. Also, the role of expectations, sentiments, and gut feelings is worth looking into as variables that could influence respondents' evaluation of innovation scenarios (Konrad and Böhle, 2019).

What lessons can be drawn for transition theory based on the results of this choice experiment, specifically related to uncertainty management? Firstly, there is a difference between how actors consider uncertainty when they make decisions (descriptively, this paper) and what should happen (normatively, as put forward by transition theory). More synthetically, we know this from behavioural decision-theory (see, for example Hodgkinson et al, 1999), here it showed up in simulated decisions on mobility transitions. Based on our experiment, we saw that the choice of moving forward with an innovation proved hardly dependent on the long-term expectation of the innovation being sustainable. That seems at odds with some normative literature. According to transition management, this choice *should* be dependent on sustainable development as a long-term goal (Loorbach, 2010). Our research seems to validate earlier research that short-term uncertainty experience related to decision tasks represses long-term uncertainty (Bruijne et al., 2010). This can be a major challenge while actors cooperate in transitions. How exactly short and long-term uncertainty affect efficacy of long-term sustainability processes requires further work and research. One way to do so could focus on implementing different reward systems for projects and organizations, with more focus on achieving long-term societal value and flexibility instead of short-term time budget and time management deadlines (Machiels et al., 2023). Another line of research could focus on applying psychological interventions, in the form of mindset change and accompanying emotions, by framing when facing uncertainty (Steg and Vlek, 2009). For example, uncertainty can be framed as an opportunity to change a system instead of a problem that leads to indecisiveness. A second lesson for transition theory is that in innovations, more emphasis should be put on governance uncertainties instead of focusing on system uncertainties when trying to develop innovations further. This research found that a lack of trust between stakeholders is the most important factor contributing to the suspension of innovation projects. This paper, therefore, underlines the learning and reflexive aspects in, for example, transition management (Loorbach, 2010), in the form of creating a coalition and understanding the development of an innovation as a product of the relationships between actors.

6. Conclusion

This paper sheds light on how uncertainty drives decision strategies on an individual level in strategic decision processes, with a focus on mobility innovation projects, by conducting a stated choice experiment. In this experiment, decision-makers had to choose an uncertainty management strategy among multiple innovation scenarios filled with uncertainties. We found that trust between collaboration partners is the most important factor for the decision to move forward with an innovation context. Uncertainty about the sustainability effects of the innovation is not significantly affecting the choice to continue with the innovation process, as respondents see the innovation project as a means to learn and explore instead of yielding long-term system change. Yet, this research focused on Dutch mobility professionals who are working on innovations and thus regard themselves in favor of innovations. Therefore, a different sample with more innovation-averse actors could lead to different results. More research is necessary to generalize the findings of this research with a more diverse sample. Conceptually, research could unpack how trust works in collaboration processes and how it can help to pull innovations through uncertainty. Also, the issue of political support, power, and leadership needs further exploring as the qualitative coding of the respondents made clear, for example, by understanding how performative statements by managers affect both experiences and handling of uncertainty in multi-actor collaborations. In sum, the applied approach in this research opens up new and fruitful ways of understanding the relationship between uncertain decision-making conditions, actor characteristics, and actual choices in transitions. Interventions for actor competencies regarding uncertainty can lead to more alignment between actor decisions and overall transition goals. We think that altering uncertainty management practices can be key in establishing a transition towards a sustainable transport system.

CRediT authorship contribution statement

Ruben Akse: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Wijnand Veeneman:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Simone Ritter:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Vincent Marchau:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Informed Consent and Confidentiality

The authors declare that the work described does not involve patients or volunteers.

Human and animal rights

The authors declare that the work described has not involved experimentation on humans or animals.

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Data Availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Generative AI and AI-assisted technologies in the writing process

This study did not use AI tools during manuscript preparation.

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Appendix A

A: Individual and organizational attitudinal statements regarding innovativeness and job tasks

	Statement	Mean (SD)	Cronbach's alpha
Individual	I think it is important to try new work methods at my work	4,41 (0,73)	0.375
	I like to work on innovative projects	4,17 (1,05)	
	I do not want to know what I am going to do at work in the next month	3,58 (1,06)	
Organizational	In my organization there is no preference for maintaining the status quo by making familiar decisions	2,68 (1,34)	0.728
	It is easy to start experiments and pilots in my organization	3,08 (1,28)	
	In my organization, there is a lot of emphasis on anticipating unexpected events (for example, in projects)	3,22 (1,27)	
	In my organization, there is a well-shared vision and/or strategy for innovations	3,08 (1,30)	
Job task	My work requires focusing on societal benefits.	4,22 (0,89)	
	My work requires focusing on commercial benefits	2,80 (1,30)	

References

Aarninkhof-Kamphuis, A., Voordijk, H., Dewulf, G., 2024. "Coping with uncertainties: challenges for decision makers in healthcare". J. Facil. Manag. 22 (5), 883–899. https://doi.org/10.1108/JFM-06-2022-0067

Ambos, T.C., Hughes, M., Niemand, T., Kraus, S., 2023. Subsidiary managers' initiative pursuit: A behavioral agency model. J. Int. Manag. 29 (3). https://doi.org/10.1016/j.intman.2023.101026

Ansell, C., Gash, A., 2008. Collaborative Governance in Theory and Practice. J. Public Adm. Res. Theory 18 (4), 543–571. https://doi.org/10.1093/jopart/mum032

Author (2019).

Author et al. (2023).

Authors. (2024).

Avelino, F., 2009. Empowerment and the challenge of applying transition management to ongoing projects. Policy Sci. 42 (4), 369–390. https://doi.org/10.1007/s11077-009-9102-6

Bjørnåvold, A., Lizin, S., Van Dael, M., Arnold, F., Van Passel, S., 2020. Eliciting policymakers' preferences for technologies to decarbonise transport: A discrete choice experiment. Environ. Innov. Soc. Transit. 35, 21–34. https://doi.org/10.1016/j.eist.2019.12.002

Bliemer, M.C.J., Rose, J.M., 2010. Construction of experimental designs for mixed logit models allowing for correlation across choice observations. Transp. Res. Part B Methodol. 44 (6), 720–734. https://doi.org/10.1016/j.trb.2009.12.004

Bogner, K., Kump, B., Beekman, M., Wittmayer, J., 2024. Coping with transition pain: An emotions perspective on phase-outs in sustainability transitions. Environ. Innov. Soc. Transit. 50. https://doi.org/10.1016/j.eist.2023.100806

Bornemann, B., Schmidt, S., Schubert, S., 2016. Governing uncertainties in sustainable energy transitions—insights from local heat supply in Switzerland. Urban Plan. 1 (3), 38–54. https://doi.org/10.17645/up.v1i3.673

Braams, R.B., Wesseling, J.H., Meijer, A.J., Hekkert, M.P., 2022. Understanding why civil servants are reluctant to carry out transition tasks. Sci. Public Policy. https://doi.org/10.1093/scipol/scac037

Braams, R.B., Wesseling, J.H., Meijer, A.J., Hekkert, M.P., 2023. Civil servant tactics for realizing transition tasks understanding the microdynamics of transformative government. Public Adm. https://doi.org/10.1111/padm.12933

Bruijne, M.D., Riet, O.V.D., Haan, A.D., Koppenjan, J., 2010. Dealing with Dilemma's: How Can Experiments Contribute to a More Sustainable Mobility System? Eur. J. Transp. Infrastruct. Res. https://doi.org/10.18757/ejtir.2010.10.3.2892

Chen, Y.-H., Lin, T.-P., Yen, D.C., 2014. How to facilitate inter-organizational knowledge sharing: The impact of trust. Inf. & Manag. 51 (5), 568–578. https://doi.org/10.1016/j.im.2014.03.007

Davies, H.J., Wu, H., Schaafsma, M., 2023. Willingness-to-pay for urban ecosystem services provision under objective and subjective uncertainty. Resour. Energy Econ. 71. https://doi.org/10.1016/j.reseneeco.2022.101344

Dewulf, A., Biesbroek, R., 2018. Nine lives of uncertainty in decision-making: strategies for dealing with uncertainty in environmental governance. Policy Soc. 37 (4), 441–458. https://doi.org/10.1080/14494035.2018.1504484

Dolmans, S.A.M., van Galen, W.P.L., Walrave, B., den Ouden, E., Valkenburg, R., Romme, A.G.L., 2023. A Dynamic Perspective on Collaborative Innovation for Smart City Development: The role of uncertainty, governance, and institutional logics. Organ. Stud. 44 (10), 1577–1601. https://doi.org/10.1177/01708406231169422

Faccioli, M., Kuhfuss, L., Czajkowski, M., 2018. Stated Preferences for Conservation Policies Under Uncertainty: Insights on the Effect of Individuals' Risk Attitudes in the Environmental Domain. Environ. Resour. Econ. 73 (2), 627–659. https://doi.org/10.1007/s10640-018-0276-2

Führer, K., d'Hont, F.M., Rouwette, E.A., Kwakkel, J.H., 2025. Participatory model-based policy exploration for the mobility transition. Transp. Res. Interdiscip. Perspect. 34, 101683. https://doi.org/10.1016/j.trip.2025.101683

Geels, F.W., 2012. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. J. Transp. Geogr. 24, 471–482. https://doi.org/10.1016/j.jtrangeo.2012.01.021

Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Policy 36 (3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Gomes, L.A. d V., Brasil, V.C., de Paula, R.A.S.R., Facin, A.L.F., Gomes, F.C. d V., Salerno, M.S., 2019. Proposing a Multilevel Approach for the Management of Uncertainties in Exploratory Projects. Proj. Manag. J. 50 (5), 554–570. https://doi.org/10.1177/8756972819870064

Graf, A., Sonnberger, M., 2020. Responsibility, rationality, and acceptance: How future users of autonomous driving are constructed in stakeholders' sociotechnical imaginaries. Public Under Sci. 29 (1), 61–75. https://doi.org/10.1177/0963662519885550

Haas, C., Kempa, K., Moslener, U., 2023. Dealing with deep uncertainty in the energy transition: What we can learn from the electricity and transportation sectors. Energy Policy 179, 113632 doi:/10.1016/j.enpol.2023.113632.

Haasnoot, M., Kwakkel, J.H., Walker, W.E., ter Maat, J., 2013. Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Glob. Environ. Change 23 (2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Hensher, D.A., 1993. Stated preference of travel choices: the state of practice. Transportation 21, 107–133.

Hess, S., Palma, D., 2019. Apollo: A flexible, powerful and customisable freeware package for choice model estimation and application. J. Choice Model. 32. https://doi.org/10.1016/j.jocm.2019.100170

Hirschhorn, F., van de Velde, D., Veeneman, W., ten Heuvelhof, E., 2020. The governance of attractive public transport: Informal institutions, institutional entrepreneurs, and problem-solving know-how in Oslo and Amsterdam. Res. Transp. Econ. 83. https://doi.org/10.1016/j.retrec.2020.100829

Hodgkinson, G.P., Bown, N.J., Maule, A.J., Glaister, K.W., Pearman, A.D., 1999. Breaking the frame: An analysis of strategic cognition and decision making under uncertainty. Strateg. Manag. J. 20 (10), 977–985. https://doi.org/10.1002/(SICI)1097-0266(199910)20

Kemp, R., Rotmans, J., Loorbach, D., 2007. Assessing the Dutch Energy Transition Policy: How Does it Deal with Dilemmas of Managing Transitions? J. Environ. Policy & Plan. 9 (3-4), 315–331. https://doi.org/10.1080/15239080701622816

Klijn, E.H., Koppenjan, J., 2016. Governance Networks in the Public Sector. Routledge, London; New York.

Kløjgaard, M.E., Bech, M., Søgaard, R., 2012. Designing a Stated Choice Experiment: The Value of a Qualitative Process. J. Choice Model. 5 (2), 1–18. https://doi.org/10.1016/s1755-5345(13)70050-2

Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Wells, P., 2019. An agenda for sustainability transitions research: State of the art and future directions. Environ. Innov. Soc. Transit. 31, 1–32. https://doi.org/10.1016/j.eist.2019.01.004

Konrad, K., Böhle, K., 2019. Socio-technical futures and the governance of innovation processes—An introduction to the special issue. Futures 109, 101–107. https://doi.org/10.1016/j.futures.2019.03.003

Kwakkel, J.H., Walker, W.E., Marchau, V.A.W.J., 2010. Classifying and communicating uncertainties in model-based policy analysis. Int. J. Technol. Policy Manag. 10 (4). https://doi.org/10.1504/ijtpm.2010.036918

Latour, B., 1996. Aramis or the love of technology. Harvard University Press, Cambridge, Massachusetts.

Lazarus, M.D., Funtowicz, S., 2023. Learning together: facing the challenges of sustainability transitions by engaging uncertainty tolerance and post-normal science. Sustain Earth Rev. 6, 18. https://doi.org/10.1186/s42055-023-00066-3

Loorbach, D., 2010. Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. Governance 23 (1), 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x

Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. Stated Choice Methods: Analysis and Application. Cambridge University Press, Cambridge.

Lundhede, T., Jacobsen, J.B., Hanley, N., Strange, N., Thorsen, B.J., 2015. Incorporating outcome uncertainty and prior outcome beliefs in stated preferences. Land Econ. 91, 296–316. https://doi.org/10.3368/le.91.2.296

Machiels, T., Goodspeed, R., Compernolle, T., Coppens, T., 2023. Creating Flexible Plans for an Uncertain Future: From Exploratory Scenarios to Adaptive Plans With Real Options. Plan. Theory & Pract. 24 (3), 366–385. https://doi.org/10.1080/14649357.2023.2220701

MacKenzie, M.K., 2021. There is no such thing as a short-term issue. Futures 125. https://doi.org/10.1016/j.futures.2020.102652

Malekpour, S., Walker, W.E., de Haan, F.J., Frantzeskaki, N., Marchau, V.A., 2020. Bridging decision making under deep uncertainty (DMDU) and transition management (TM) to improve strategic planning for sustainable development. Environ. Sci. & Policy 107, 158–167. https://doi.org/10.1016/j.envsci.2020.03.002

Martiskainen, M., Sovacool, B.K., 2021. Mixed feelings: A review and research agenda for emotions in sustainability transitions. Environ. Innov. Soc. Transit. 40, 609–624. https://doi.org/10.1016/j.eist.2021.10.023

McFadden, D., 1974. Conditional logit analysis of qualitative choice behaviour. In: Zarembka, In.P. (Ed.), Frontiers in Econometrics. Academic Press, New York, pp. 105–142.

Meijer, I., Hekkert, M.P., 2007. Managing uncertainties in the transition towards sustainability: Cases of emerging energy technologies in the Netherlands. J. Environ. Policy Plan. 9 (3-4), 281–298. https://doi.org/10.1080/15239080701622865

Mokas, I., Lizin, S., Brijs, T., Witters, N., Malina, R., 2021. Can immersive virtual reality increase respondents' certainty in discrete choice experiments? A comparison with traditional presentation formats. J. Environ. Econ. Manag. 109. https://doi.org/10.1016/j.jeem.2021.102509

Molin, E.J.E., Timmermans, H.J.P., 2010. Context Dependent Stated Choice Experiments: The Case of Train Egress Mode Choice. J. Choice Model. 3 (3), 39–56. https://doi.org/10.1016/s1755-5345(13)70013-7

Muhlbacher, A.C., Juhnke, C., 2013. Patient preferences versus physicians' judgement: does it make a difference in healthcare decision making? Appl. Health Econ. Health Policy 11 (3), 163–180. https://doi.org/10.1007/s40258-013-0023-3

Pel, B., 2022. A transitions theory perspective on transport innovation. In: Van Wee, In.B., Annema, J.A., Köhler, J. (Eds.), Introduction to Innovations in Transport. Edward Elgar Publishing, pp. 14–34.

Pelzer, P., Frenken, K., Boon, W., 2019. Institutional entrepreneurship in the platform economy: How Uber tried (and failed) to change the Dutch taxi law. Environ. Innov. Soc. Transit. 33, 1–12. https://doi.org/10.1016/j.eist.2019.02.003

van Rijnsoever, F.J., Meeus, M.T.H., Donders, A.R.T., 2012. The effects of economic status and recent experience on innovative behavior under environmental variability: An experimental approach. Res. Policy 41 (5), 833–847. https://doi.org/10.1016/j.respol.2012.02.005

van Rijnsoever, F.J., Kempkes, S.N., Chappin, M.M.H., 2017. Seduced into collaboration: A resource-based choice experiment to explain make, buy or ally strategies of SMEs. Technol. Forecast. Soc. Change 120, 284–297. https://doi.org/10.1016/j.techfore.2017.03.015

Rose, J.M., Bliemer, M., 2014. Stated choice experimental design theory: the who, the what and the why. In: Hess, In.S., Daley, A. (Eds.), Handbook of Choice Modelling. Edward Elgar Publishing Limited, Cheltenham, UK, pp. 152–177.

Rose, J.M., Bliemer, M.C.J., 2009. Constructing Efficient Stated Choice Experimental Designs. Transp. Rev. 29 (5), 587–617. https://doi.org/10.1080/01441640902827623

Schot, J., Geels, F.W., 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technol. Anal. & Strateg. Manag. 20 (5), 537–554. https://doi.org/10.1080/09537320802292651

Scoones, I., Stirling, A. (Eds.), 2020. The Politics of Uncertainty. Routledge, Londen; New York.

Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Res. Policy 41 (6), 1025–1036. https://doi.org/10.1016/j.respol.2011.12.012

Sondeijker, S., Geurts, J., Rotmans, J., Tukker, A., 2006. Imagining sustainability: the added value of transition scenarios in transition management. Foresight 8 (5), 15–30. https://doi.org/10.1108/14636680610703063

Stanton, M.C.B., Roelich, K., 2021. Decision making under deep uncertainties: A review of the applicability of methods in practice. Technol. Forecast. Soc. Change 171, 120939. https://doi.org/10.1016/j.techfore.2021.120939

Steg, L., Vlek, C., 2009. Encouraging pro-environmental behaviour: An integrative review and research agenda. J. Environ. Psychol. 29 (3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Train, K.E., 2003. Discrete choice methods with simulations. Cambridge University Press, Cambridge, UK.

Turnheim, B., Sovacool, B.K., 2020. Exploring the role of failure in socio-technical transitions research. Environ. Innov. Soc. Transit. 37, 267–289. https://doi.org/10.1016/j.eist.2020.09.005

de Vasconcelos Gomes, L.A., da Silva Barros, L.S., 2022. The role of governments in uncertainty orchestration in market formation for sustainability transitions. Environ. Innov. Soc. Transit. 43, 127–145. https://doi.org/10.1016/j.eist.2022.03.006

Veenma, K., Leendertse, W., Arts, J., 2023. Room for uncertainty in infrastructure planning: How continuous certainification by decision makers results in more uncertainty. Trans. Assoc. Eur. Sch. Plan. 7 (1), 36–44. https://doi.org/10.24306/TrAESOP.2023.01.004

Von Wirth, T., 2025. Ontological (in) security and sustainability transitions: A theoretical perspective and future research prospects. Environ. Innov. Soc. Transit. 57, 101042. https://doi.org/10.1016/j.eist.2025.101042

Zandvoort, M., van der Brugge, R., van der Vlist, M.J., van den Brink, A., 2019. Dealing with uncertainty in collaborative planning: developing adaptive strategies for the IJsselmeer. J. Environ. Plan. Manag. 62 (2), 248–265. https://doi.org/10.1080/09640568.2017.1409196