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Perceived risk of lock-in in the front-end phase of major transportation projects

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Abstract
Lock-in is defined as the tendency to continue with an inefficient decision or project proposal. The front-end phase is critical to project success, yet most studies have focused on lock-in in the implementation phase. Moreover, little is known about the way in which decision-makers perceive the risk of lock-in. In this paper we identify determinants of lock-in in the front-end phase and we reveal decision-makers' perceptions of risk of lock-in. Our findings show that risk attitudes towards lock-in vary with the level of risk aversion. However, this is not sufficiently acute to drive the level of regret needed to avoid lock-in. This implies that decision-makers do not accurately assess the risk of lock-in and as such their risk perceptions are a mediating factor in the formation of lock-in. Based on escalation of commitment, path dependency, and prospect theory, the main contribution lies in providing a more comprehensive understanding of lock-in in the front-end phase.

Keywords Lock-in · Escalation of commitment · Path dependency · Decision-making · Risk perception · Major transportation projects

Introduction

Governments worldwide are faced with the risk of significant cost overruns when delivering large infrastructure projects (e.g. Flyvbjerg et al. 2002; Odeck 2004; Love et al. 2016). The failure to deliver projects within budget is often attributed to problems in the front-end of projects (e.g. Williams et al. 2019), the decision-making and planning phase, where risks and uncertainty are often not adequately addressed (Williams and Samset 2010; Ramjerdi and Fearnely 2014). Recently, there has been an increase in studies focussing on front-end project planning, addressing for example stakeholders' framing of project value (Martinsuo et al. 2019), project value through co-creation (Liu et al. 2019; Smyth et al. 2018), project

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management flexibility (Jalali Sohi et al. 2019), the risk of perverse incentives (Volden 2019), and organisational support (Zwikael and Meredith 2019).

This paper also addresses this important front-end phase of transportation projects by focusing on lock-in, defined as the persistence with a project proposal even before the formal decision to build has been taken (Cantarelli et al. 2010). With lock-in the *real* decision to build is often made before the *formal* decision to build, at a time when the estimated costs are typically much lower. Consequently, projects are approved that are unlikely to be completed within budget. Although not a formal commitment, in practice this lock-in causes irreversibility of the decision. This type of lock-in is similar to the cognitive lock-in studied in economic geography literature, whereby "actors inflexibly focus on a dominant path and common viewpoint" (Wood and Reynolds 2011: 2474).

There may be situations where it may be rational to commit to a specific project proposal despite negative feedback on the plan. Tiwana et al. (2006) refer to this situation as *warranted* continuation. With warranted continuation it may be rational to continue even though the project plan itself is no longer economically viable, when one considers the value of other options and takes a wider portfolio and longer term perspective, where it may have strategic value to the organisation. The project may contribute to organisational objectives that would otherwise not be achieved. In case of warranted continuation, decision-makers make a conscious decision about the project plan and as such can still reverse the decision if desired. In contrast, this paper is interested in lock-in as a possible explanation for project failures, it considers *unwarranted* continuation and irreversibility.

Two of the main explanations for this lock-in phenomenon proposed in the literature are escalation of commitment (e.g. Staw and Ross 1987; Brockner 1992) and (organisational) path dependence (e.g. Sydow et al. 2009; Vergne and Durand 2010; Schreyögg and Sydow 2011). Escalation of commitment is defined as the "tendency for individuals to become overly committed to escalation situations" (Staw and Ross 1987: 41). Organisational path dependence is the process that produces persistence. It is defined as the process of increasing reduction of choices that results in lock-in once a dominant decision is reinforced while other potentially more efficient decisions are excluded (Koch 2011).

Escalation of commitment focuses on *what* caused the escalation, while path dependence focuses on *how* over time the project development process results in lock-in. Hence the theories are complementary (Sydow et al. 2009; Koch 2011; Schreyögg and Sydow 2011) and should be considered in conjunction to fully understand the lock-in phenomenon.

Most studies have focused on the drivers of lock-in in the implementation phase (e.g. Ross and Staw 1986, 1993; Maxwell et al. 1997; Drummond 1999; Winch 2013) such as overconfidence, sunk costs, perceived need for self-justification, denial, and completion effects (Drummond 2014). However, there is a need to "identify various factors that may operate during different stages of the project" (He and Mittal 2007: 236). So far little is known about factors that contribute to the emergence of lock-in in the front-end phase. The front-end is still often "unclear and poorly understood" (Williams et al. 2019: 4) and an increase in the understanding of "what goes on in the front-end" is needed. Moreover, the risk of lock-in and the resulting irreversibility of investment decisions is weakly understood by policy makers (Ramjerdi and Fearnley 2014). A difference in decision-makers' perception and assessment of risk (Keil et al. 2008) may be an explanation for why projects go awry (Wallance et al. 2004). However, little is known about the way in which decision-makers perceive the risk of lock-in.

This paper aims to provide a more complete understanding of the risk of lock-in by expanding the current theoretical model of lock-in. It expands the model by including the front-end phase and perceived risk of lock-in to explain the formation of lock-in. Two

research objectives facilitate the achievement of this aim. First, to review the existing literature to identify determinants that contribute to the lock-in formation in the front-end phase. Second, to reveal different ways in which decision-makers perceive the risk of lock-in in the front-end phase. Besides internal and external escalation and path dependency determinants, decision-makers' attitude towards the risk of lock-in can affect the lock-in process and consequent project decision path. By using utility and prospect theory we propose a new dimension of perceived risk to the framework of lock-in.

Two research questions are considered. (1) Which escalation and path dependency determinants may contribute to lock-in in the front-end phase and how may they influence each other? (2) How do decision-makers perceive the risk of lock-in and what characterises and differentiates risk perceptions of lock-in in the front-end phase?

The paper is organised as follows. In section "Theoretical background to lock-in", we discuss the theoretical background of lock-in covering escalation of commitment, organisational path dependency, and risk perceptions. In section "Research method", we present the research methodology and research context. The section "Analysis" provides the details and results of the analysis, while the "Findings" section presents the findings of the study including the derived perceptions. In section "Discussion and implications", we discuss these findings and their implications and we suggest future research avenues. Lastly, in section "Conclusion" we present the conclusions of this study.

Theoretical background to lock-in

This section sets out three theoretical explanations why lock-in may occur in the front-end phases of project development: escalation of commitment; path dependency; and utility theory.

Escalation of commitment

This section reviews the literature on escalation of commitment determinants. It aims to identify determinants that may result in lock-in in the front-end phase of projects.

Project determinants involve characteristics that affect the financial value of persisting with a project or withdrawing from it. Project determinants include decision risk (inherent uncertainty regarding the likelihood of incurring a loss) and positive performance trend information (the presence of an increasing, but still low, probability of success) (Sleesman et al. 2012). These determinants have the strongest effect in the intermediate phases (when the project is about half complete) whereas their effect on escalation of commitment in the early planning phases is relatively low (He and Mittal 2007).

In contrast, three determinants that are particularly influential in the emergence of lock-in in the front-end phase as compared to the later phases include information quality, opportunity costs, and expressed preference. The project planning phase is often characterised by high levels of uncertainty. As a result decision-makers tend to delay withdrawal because they prefer to wait until more information becomes available to make a persistence or withdrawal decision (Bragger et al. 1998). Opportunity costs provide decision-makers with information about the costs foregone by continuing with a specific project plan. Opportunity costs are the costs representing the missed benefits of alternative projects that could have been financed. Providing decision-makers with information about these opportunity costs could influence their decision (Northcraft and Neal 1986). Decision-makers

who consider these opportunity costs in an explicit manner are less likely to escalate their commitment and become locked-in to the decision (Northcraft and Neale 1986; Harvey and Victoravich 2009).

A related concept concerns the *expressed preference* for initial decisions. This implies that decision-makers will invest more resources if they prefer the project proposal (Schulz-Hardt et al. 2009). Expressed preference can be considered a driver for project approval and contribute to the formation of lock-in in the planning phase while it can be considered a driver for project completion in the implementation phase.

Turning to psychological determinants, the two main determinants are the need for self-justification and previous resource expenditures (sunk costs) (Sleesman et al. 2012). With *self-justification*, individuals will spend more resources because they feel the need to show their initial decision was correct (Brockner 1992). Self-justification can explain how decision-makers persist with a project decision after the *real* decision to build is taken (informal decision) and why they are unlikely to withdraw the project decision at the later stage of *formal* decision to build.

The influence of *sunk costs* on escalation of commitment is widely acknowledged in the literature (e.g. Brockner 1992; Keil et al. 1995). Decision-makers typically do not want to be seen wasting resources, and therefore try to justify their decisions by increasing their commitment to it (Arkes and Blumer 1985). Schwenk and Tang (1989) also referred to this as retrospective rationality, decision-makers bias their attitudes towards the decision they have made to justify their behaviour. This determinant is typically considered in the implementation phase when large investments have been made. However, due to the long decision-making nature of major projects, time and effort can also be considered sunk costs contributing to the formation of lock-in in the front-end phase. Decision-makers do not want to admit that the time they have invested had been a waste (Soman 2001).

Social determinants can be considered as an *external* need for justification. The project context may lead to decision-makers' desire to be seen to behave in a consistent manner which could result in lock-in. For example, a minister may prefer to stick to previously expressed political preference (i.e. to support a project proposal) because they do not want to lose credibility or be accused of inconsistent behaviour (e.g. Cayton 2017). The degree of initial public commitment and the extent to which public statements include references about the wisdom of an initial decision are factors that relate to increased persistence (Schwenk and Tang 1989). Decision-makers who are facing high pressures from stakeholders are more likely to persist in order to manage the impressions others have of them and to save face (e.g. Brockner et al. 1981). A second social determinant that can result in lock-in in the front-end phase is *resistance*. Major projects are often subject to public scrutiny and outside evaluations. The relative level of initial resistance to the decision influences the degree of persistence (Schwenk and Tang 1989). In the implementation phase, criticism is mostly directed at performance measures such as cost and schedule. In contrast, in the planning phase resistance is mostly directed towards the project proposal, whereby decision-makers feel the need to justify the project decision and hence risk becoming locked-in.

Lastly, structural determinants are defined by Staw and Ross (1987: 60) as "the structural features of an organisation and its interaction patterns". In the implementation phase this concerns determinants such as administrative inertia or institutionalisation; projects that are embedded in or tied to an organisation's core values are less likely to be halted. In contrast, one of the main structural determinants in the decision-making phase concerns political influences. If a project plan does no longer appear to be feasible on economic grounds, political support may lead to persistence with a project proposal. It may prevent

re-examination of the project decision or the project evaluation may be positively biased (Staw and Ross 1987).

Path dependence

For the study of (major) projects, path dependence may occur at the micro level (Vergne and Durand 2010) and is often referred to as organisational path dependence (Sydow et al. 2009; Schreyögg and Sydow 2011). Organisational path dependence is the process of "an increasing reduction in a range of choices at the level of organisational resources and capabilities" (Koch 2011: 340). When positive feedback about a project proposal is received, this process of reducing options may be desired as it may increase the efficiency of organisational processes. However, such reduction of options becomes a problem when it is the result of the tapering feature of organisational path dependence. In those cases project choices become increasingly restricted in the process of following a path (Koch 2011). It then results in one dominant project proposal being reinforced over time excluding other potential more efficient project plans.

The process of organisational path dependence consists of three stages (Sydow et al. 2009; Koch 2011). In the first stage of preformation, some initial conditions are set, but there is still a broad scope of action with multiple choices available. When an initial decision is made, the process moves on to the second stage of formation. In this stage, the range of options is reduced to the extent that alternatives are barely considered. The third stage of lock-in emerges when the process has become irreversible through increasing returns. For example, the costs of deviating from a decision path has become so large, that changing the course of action is no longer an option (Sydow et al. 2009).

Except for two case studies by Hellström et al. (2013) and Aaltonen et al. (2017) there are surprisingly few studies that consider organisational path dependence at the project level. There seems to be a lack of knowledge on how events during the early stages of major projects follow a path dependent process and may result in lock-in.

One of the main determinants of organisational path dependence in the context of major projects is the *closure of project alternatives*. The closure of alternatives could be the result of adaptive expectation effects (Sydow et al. 2009; Schreyögg and Sydow 2011). These are self-reinforcing mechanisms that strengthen path formation when, in situations of high levels of uncertainty, decision-makers are more sensitive to relying on decisions and project proposals that seem to be preferred by others (Aaltonen et al. 2017).

Agreements and decision support are two other organisational path dependence determinants that may act as self-reinforcing mechanisms in the planning phase (Cantarelli et al. 2010). Agreements can formalise commitment to decisions even before the actual go-decision has been made, because it implies an expectation of stakeholders to adopt and support specific arrangements. Decision support refers here to the support for the *real* (informal) decision to build, thus the decision before the formal decision to build is taken. Decision-makers are informally committed if they support the project decision even if new information about the project plan becomes available that shows the project is no longer feasible. In principle it could still be possible to reverse the project decision. However, decision support explains why in practice decision-makers do not deviate from the path and change their decision at the moment of formal decision to build. So far only a few studies have explored the link between decision support and lock-in. They confirmed decision support increases the risk of lock-in either by the

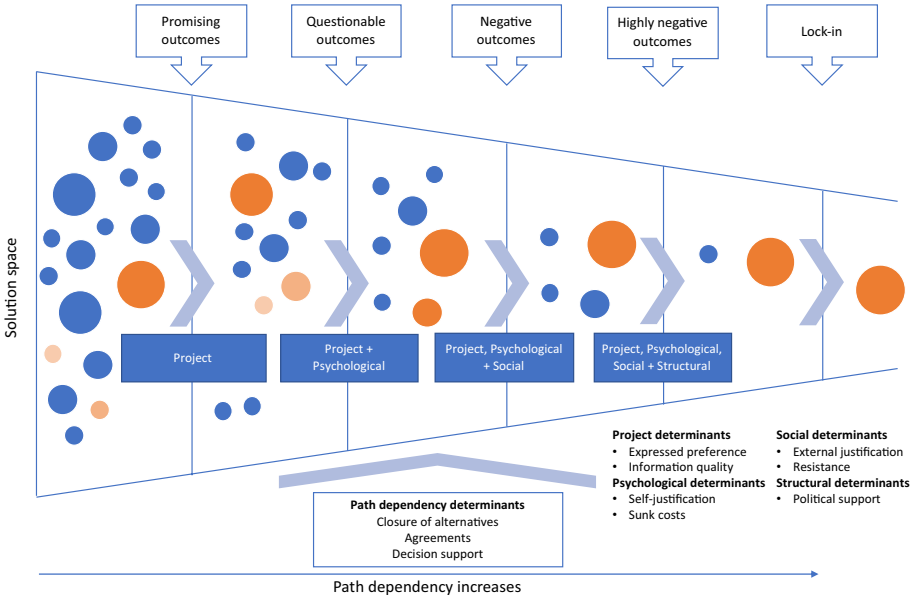

Fig. 1 Lock-in process in the front-end phase (based on Staw and Ross 1987; Sydow et al. 2009)

tendency to bias results in favour of the supported project proposal (Tal and Cohen-Blankshtain 2011) or by trying to keep on a decision path and avoid termination (Guler 2007).

Conceptual model

Figure 1 shows how the formation of lock-in in the front-end phase of major projects may take place by the escalation of commitment and path dependency determinants revealed above. Over time, different determinants play a role that contribute to the lock-in formation, for example, in the early phases it is typically project determinants (Staw and Ross 1987). The funnel shows how organisational path dependency gradually occurs over time due to different determinants leading to a reduction of the solution space (Koch 2011).

This study investigates to what extent this risk of lock-in as presented in Fig. 1 is perceived as such by decision-makers.

Figure 2 shows the relation between escalation and path dependency determinants.

Decision support, expressed preference, and political support can result in making agreements or closing project alternatives. These two path dependency determinants can consequently lead to decision-maker's desire to justify their decision, to themselves (self) or to others (external).

Agreements could also contribute to the sunk cost effect and consequently result in closure of alternatives. Decision support has an indirect relation with the escalation determinants through its relation with the determinant closure of alternatives.

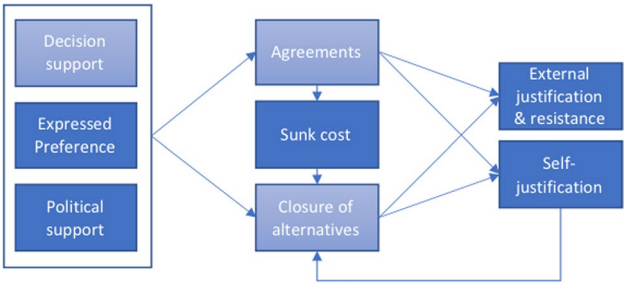

Fig. 2 Relations between escalation of commitment (dark shaded) and path dependency determinants of lock-in (light shaded)

The relationships between different escalation determinants are few. Where literature has discussed potential relations (Sleesman et al. 2012), these are between variables that have not been part of our study because they do not apply in the front-end phase.

Utility theory and risk perception

Whilst there are examples in the literature around utility, escalation of commitment, and path dependence, these often focus on the impact of one particular determinant. For instance, some studies used expected subjective utility theory to explain a specific project determinant of escalation of commitment (e.g. Kahneman and Tversky 1979; Bragger et al. 1998; Schulz-Hardt et al. 2009). However, there have been few studies which have considered theories in a holistic way, and explicitly considered how and why different decision-makers with different attitudes to risk might have different attitudes or responses to lock-in. The previous section has illustrated the escalation of commitment and path dependency theories. In this section we use prospect theory to reveal perceptions of risk caused by these escalation and path dependency determinants of lock-in.

Prospect theory states that "people underweight outcomes that are merely probable in comparison with outcomes that are obtained with certainty" (Kahneman and Tversky 1979: 265), resulting in risk seeking behaviour when choices involve a sure loss. When decision-makers receive negative feedback about a project plan, the decision to be made is one between abandoning the project plan or continuing with the project proposal. Decision-makers would perceive the decision to abandon the project as a sure loss which results in risk-seeking behaviour and induces escalation of commitment behaviour (Drummond 1996; Keil et al. 2000). This shows how the perceived risk of lock-in may shape decision-makers risk preferences. In other words, if the risk of lock-in is not acknowledged, persisting with the project despite negative feedback is not considered a loss because decision-makers hope to turn the situation around and achieve a positive outcome.

The risk-averse decision-maker will perceive the risk of lock-in to be higher than a risk-seeking decision-maker. With options through alternative project pathways diminishing due to the various determinants previously discussed, they would anticipate regret over continuing with the project decision (Ku 2008; Wong and Kwong 2007). They will adopt a strategy of minimising the maximum regret they anticipate ('minimax regret strategies') (Savage 1951), whereas risk seeking decision-makers do not anticipate such regret increasing their commitment and lock-in. Clearly, two decision-makers

with different attitudes to risk and thus different minimax regret strategies will have quite different attitudes to the risk of lock-in.

There is some useful extant planning literature but none which utilises this to explain the role of different attitudes on this lock-in outcome. Su and Tung (2012) refer to *opportunity loss* in complex projects to help understand alternative project rankings, but do not explicitly refer to outcomes under lock-in to any one alternative. Hung and Ryu (2008) argue that the decision-maker's risk preference is path dependent but apply this to the field of supply chain management and inventory decisions. Several studies have also used or reviewed regret theory and specifically the minimax criterion to examine location decisions (e.g. Li et al. 2018; Wang et al. 2008) but, these have been in a decision support context rather than looking at the extent to which those location decisions became irreversible because of lock-in.

In the next section we will outline the research method to reveal decision-makers' perceived risk of lock-in.

Research method

Rationale of Q-methodology

This study is concerned with decision-makers' perceptions of the risk of lock-in. Particularly we aim to reveal patterns of perceptions and describe the characteristics of these patterns and their differences.

The study of people's perceptions is subjective and complex. In addition, the risk perceptions that we aim to reveal in this study typically encompass a complex and dynamic interplay of escalation and path dependency determinants. Moreover, perceptions may not be clearly defined a priori by the researcher or readily articulated by research participants. Therefore, in order to answer our research questions, a methodology is required that can investigate subjectivity in an unbiased way, can deal with the complex interplay of factors, and can reveal patterns of risk perceptions.

Q-methodology (described in the next sections) was selected because it meets these requirements. The method was adopted in this research for the following reasons. First, the method is particularly suitable for the systematic study of subjectivity, that is peoples' perceptions and beliefs, by providing procedures to reveal and examine various viewpoints (Brown 1993). Second, the method provides a way to deal with the interplay of variables. With Q-methodology participants evaluate and interpret statements in relation with each other providing a means to reveal wider risk perceptions. This is not possible with typical survey methods, whereby statements are considered in isolation. Third, Q-methodology generates diverse patterns of perceptions that are not easily characterised by predefined attitudes. As such it can reveal the complex and undefined risk perceptions of lock-in. Fourth, Q-methodology is particularly suitable for small sample sizes. It is less influenced by low response rates (Brown 1980, 1993; McKeown and Thomas 1988) and it does not bias results or the reliability of the results (Brown 1993; Valenta and Wigger 1997: 501). This study is prone to have a small sample size due to the limited number of decision-makers with in-depth knowledge and active involvement in the decision-making of a major project. In the sections that follow, we will discuss the Q-methodology approach.

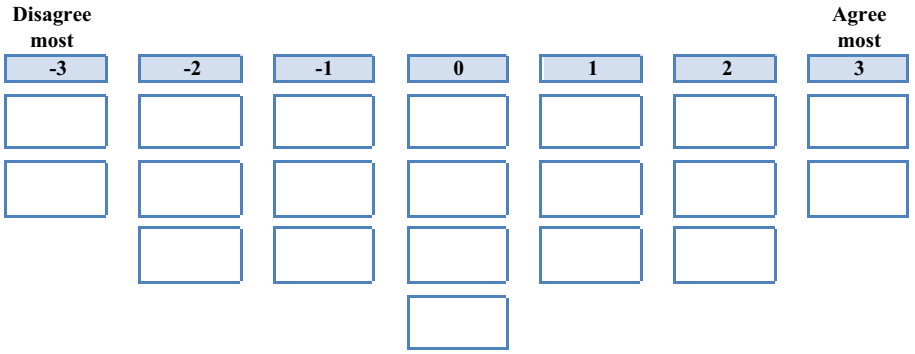

Fig. 3 Score sheet for Q-sorting 20 statements

Overview Q-methodology

Q-methodology is a hybrid qualitative-quantitative approach originally developed by William Stephenson as a means to investigate subjective viewpoints (Brown 1986, 1993). In this method, the participants are the variables, compared to traits or items in conventional factor analysis. Participants are asked to rank items within a subject domain, after which the participants' item configurations (or rank orderings) are intercorrelated and factor analysed. The resulting factors represent the shared viewpoints. Q operates on the assumption of 'finite diversity', i.e. there is a limited number of viewpoints within a subject domain. Q works on this assumption and attempts to reveal those viewpoints in a structured and interpretable manner (Barry and Proops 1999: 339).

Q-methodology approach

The first stage in Q-methodology involves defining the concourse from which the sample of statements is drawn. The concourse is the flow of communicability surrounding any topic (Brown 1993). From the concourse, a set of statements (called Q-sample) is generated that is representative of the range of existing opinions about the topic.

In the second stage participants receive a randomly numbered set of statements from the Q-sample. They are asked to rank order these statements on a score sheet (agree to disagree) (see Fig. 3) according to their beliefs.

The score sheet is represented as a distribution with the blank cells indicating where statements should be placed along the continuum, thus indicating the number of statements participants can rank for a certain value of the distribution. For example, the distribution allows for the ranking of two statements as agree most (score of 3), three statements as agree (score of 2), and three statements as slightly agree (score of 1). In Q-methodology these categories are represented by numeric values indicating the extent of (dis)agreement. With seven categories this results in ranking values from -3 (disagree most) to $+3$ (agree most). The resulting rank-ordering is referred to as Q-sort, it is the viewpoint of that individual. Participants are given the opportunity to provide additional comments on the statements and study in general.

In the third and last stage, the Q-sorts are correlated and factor-analysed. Correlation analysis is used to identify which respondents share similar viewpoints. Persons whose Q-sorts correlate share certain perceptions. Stephenson (1935: 21) explains "if each individual has his or her own specific likes and dislikes, then the individuals will not correlate except by chance alone." Thus in Q-methodology participants (based on their Q-sorts) are correlated whereas in traditional factor analysis traits (such as experience, age) are correlated.[1] Stephenson (1935: 2) continues "if significant correlations appear, they could be factorised." The objective of the factor analysis is to obtain the groupings of data arrays (numerical data of the Q-sorts) that are highly correlated. The factors that are extracted represent the common perceptions. Factor loadings indicate the extent to which people are associated with a specific factor (viewpoint) (Valenta and Wigger 1997). Individuals with similar views on the topic would then share the same factor.

In order to describe the identified factors (viewpoints), factor scores are converted into an array of scores corresponding to those used in the original Q-sort continuum to compute the ideal type Q-sort for that factor. An idealised Q-sort represents how a hypothetical person with a 100 percent loading on the factor would have ordered the statements.

Case study

We adopted a case study approach to gain an in-depth understanding of the complex phenomenon of lock-in. The exploratory nature of our study into decision-makers' perceptions fits well with this qualitative method. Moreover, the value of a case study lies in "its ability to encompass a wide range of variables" (Drummond 1996: 24) making it a suitable method for our research which includes a variety of escalation of commitment and path dependency variables.

Phenomena on major projects are contextually specific (Winch 2013). We have therefore selected a single case study because single case studies are especially suitable to gain a deep understanding of the context. In fact, many empirical case studies on escalation of commitment are single case studies (e.g. Expo 86 World Fair and the Shoreham Nuclear Power Plant (Ross and Staw 1986, 1993), Taurus (Drummond 1996, 1999), Great Whale hydroelectric complex (Maxwell et al. 1997) and the Channel Fixed Link (Winch 2013)). The context-dependent knowledge and explorative insights that can be gained from a single case are highly valuable (Flyvbjerg 2006).

To explore the perceptions of the risk of lock-in, we need to understand the context specificity of lock-in. Thus, in selecting a case, a project should have evidence of lock-in and it needs to be well documented to trace the lock-in formation. The Betuweroute project (see next section) meets both of these criteria. Several academic papers as well as semi-annual project progress reports and governmental reports by the Temporary Committee for Infrastructure Projects (TCI 2004) are publicly available. This approach is similar to the 'revelatory' case selection from Yin (2014) whereby a case represents an opportunity to study a phenomenon that is otherwise inaccessible or undisclosed. In the next section, we present the key events in the decision-making of the Betuweroute project.

[1] This inversion of conventional factor analyses also let to naming the technique as 'Q', to make a distinction with the more familiar R methodology.

Research context

The Betuweroute is a freight-transport railway line of about 160 km between the port of Rotterdam in the Netherlands and the European hinterland. It was opened in 2007 after a long decision-making process. As long ago as the early 1980s, various proposals were drawn to construct a new railway line. It was aimed to improve the connection between the 'main port' Rotterdam and the European hinterland while at the same time strengthening the national economy (Priemus 2007).

In 1990 the Betuweroute project proposal was included in the *SVV2* (Second Transport and Structure Plan), as a solution to the problem of insufficient railway capacity for freight transport to accommodate expected future growth. The SVV2 is a policy plan for the development of transport in the Netherlands (Priemus 2007; TCI 2004), it is not legally binding. The Ministry of Transport and the Dutch Railway Company (NS) decided to investigate this project proposal in more detail, with the NS investigating the specific implementation of the Betuweroute in a project memorandum (Ministry of Transport 1996–2007; TCI 2004).

Concerns about the possible negative impacts of the Betuweroute increased and various pressure groups including a national body were initiated. At the same time, the steering committee of the Betuweroute project considered the need to accelerate the decision-making on the project.

The Betuweroute project proposal was subject to heavy criticism, with economic viability and landscape issues (due to the proposed project crossing a nature area) being heavily debated (TCI 2004; Roscam et al. 1999). There was also a lot of resistance because of the environmental worries about noise and dangerous chemical spills. Another major controversy concerned project alternatives. Alternative rail project plans such as a joint hinterland connection by rail between Rotterdam and Antwerp, increased utilisation of the existing railway network, and underground construction, were not taken seriously or considered too late in the process to make an impact on the decision to proceed with the Betuweroute project proposal (Priemus 2007). Projects to improve this hinterland connection focusing on other modes such as inland water transport were never considered fair alternatives either (Priemus 2007).

In 1992 the Cabinet decided to follow the PKB1 procedure (Key Planning Decision, part I) for the project, which details part of national policy. They pursued a two-track policy; calling for the publication of the policy plans (PKB1) while at the same time conducting additional research to justify the project plan. Besides the PKB1 procedure, two new pieces of legislation (the New Track and NIMBY laws) were planned to prevent further delay to projects or, in other words, to speed up the decision-making process (Priemus and Visser 1995).

In 1993 the so-called *Warnemünde agreement* was signed, an agreement with Germany to provide a connection with the German rail network. Under this agreement, the Netherlands were to undertake several activities, amongst others the construction of the Betuweroute project and the construction and expansion to the German border (Priemus 2007).

In 1996 finally after a long decision-making process the formal decision to build the Betuweroute project was taken.

Research validity

We followed guidelines on Q-methodology to address research validity (Valenta and Wigger 1997). Content validity was ensured by conducting a thorough literature review and documentation search on the phenomenon of lock-in and the decision-making of the Betuweroute project. The use of this type of material also ensures face validity in the formation of the statements; statements are not affected by the wording of participants. The post-sorting opportunity to comment and elaborate on their sorting showed that participants fully comprehended the task and contents. It did not reveal any dissatisfaction by participants, which is an indication of the validity of the results in Q-studies (Tielen et al. 2008). Besides content and face validity, issues of validity "fade" in Q-methodology (Brown 1993; Dziopa and Ahern 2011). This is because the Q-sorting procedure is used to assess individual's perception and there is no external criterion to appraise the validity of a persons' own perspective (Brown 1993).

Analysis

Developing the Q-sample

As the first step in a Q-study we defined the concourse and developed the Q-sample. In our research, the concourse is the decision-making of the Betuweroute project and how escalation of commitment and path dependency determinants contributed to lock-in. We used a hybrid method of concourse development combining items that emerged from scientific literature on lock-in and items that emerged from documentation about the Betuweroute project. This section describes the concourse and identifies the determinants that contributed to lock-in in the decision-making of the Betuweroute project. We developed the Q-sample by generating statements from this concourse.

Even before the formal decision to build was taken in 1996 various events took place that may have contributed to lock-in. As explained in the previous section, early on in the decision-making the focus was solely on railway connections as an opportunity to develop Rotterdam harbour (Priemus 2007; TCI 2004). This created an excessive focus on the Betuweroute project itself and shifted attention away from the problems with insufficient railway capacity for freight transport. Studies by TCI (2004) and Priemus (2007) argue that the phenomenon of "solutions searching for problems" played an important role in the decision-making of the Betuweroute. The excessive focus on the Betuweroute illustrates the expressed preference determinant. In an interview with the Gelderlander, the Chairman of the commission on the Betuweroute confirmed that the decision for the project was already taken and that arguments to support the project plan were only provided later on in the decision-making process (De Gelderlander 1995 in Roscam et al. 1999: 13).

As a response to the heavy criticism on the project proposal, rather than evaluating and examining the facts and figures of the Betuweroute, the Cabinet focused on justifying its decision of principle (i.e. the decision to continue with the Betuweroute project plan) (TCI 2004) (resistance determinant). For example, any investigations were to be based on the demand forecasts provided by the NS, and as these were highly positive, it resulted in subsequent studies also showing a positive evaluation and thus providing a justification for the Betuweroute decision. Roscam et al. (1999: 10) refers to reports that seemed to have been

written according to desired messages and a Government who does not want to engage in any discussions but who wants to enforce a decision that represents a "point of no return".

Pestman (1999) introduces the "mobilisation paradox": the social controversies in the project led to new knowledge, facts, and circumstances, however, due to the controversy and political viewpoints, these became less accepted by those responsible, consequently reducing the probability of deviating from the Betuweroute decision path. The influence of resistance is also aptly illustrated by Pestman (1999: 206): "…it becomes increasingly difficult for politicians to change their opinions because of their fear of losing credibility" illustrating the external justification determinant.

On several occasions the Cabinet appeared biased towards the Betuweroute decision, with important ministers being supporters of the project plan (TCI 2004), illustrating the presence of the political support determinant. As new information on project plans became available from both project opponents and proponents, they were not critically evaluated. For example when Netherlands Bureau for Economic Policy Analysis (TCI 2004: 194) concluded that the freight capacity was higher than expected allowing for phased implementation, this was not being considered. In face of contradictory information, the Cabinet always let positive interpretation prevail (TCI 2004). By portraying the situation in a positive manner, the risk of the plan reduces, increasing the probability of decision-makers staying with a decision path (Schoorman et al. 1994). This shows the self-justification determinant of lock-in by information framing. However, the Minister at the time did not share this view of optimistic presentation of the project by the Cabinet (TCI 2004).

Throughout the planning phase the arguments in favour of the Betuweroute project remained poorly founded. Information acquisition generally reduces the tendency to escalate commitment (Bowen 1987; Bragger et al. 2003), conversely, a lack of information may contribute to lock-in formation. The available information was not sufficient to take a justified decision and this was used as a reason to delay the withdrawal decision. The fact that environmental and economic objectives had not been met proved no reason to revise the project decision (Ministry of Transport 1996–2007; TCI 2004). Instead decision-makers tried to justify their decision by insisting it was a "strategic decision" (Roscam et al. 1999). It was said to be essential to meet economic and environmental interests (TCI 2004). Moreover, the project was believed to be necessary to achieve long-term policy goals such as strengthening the image of the Harbour of Rotterdam and the position of the Netherlands in the European distribution network (Pestman 1999).

The long decision-making phase may have enforced the sunk cost effect; time and effort spent on the decision-making of the project did not want to be seen as having been wasted. The Cabinet pressured the parliament by referring to the time spent on the decision-making and that postponing the decision-making was not desired (TCI 2004).

The government introduced new legislation and procedures to speed up the decision-making on the Betuweroute. The two-track policy that was adopted may have contributed to the lock-in result. It allowed decision-makers to continue with the project plan and even take some first steps into implementation making it harder to reverse the decision-making process (TCI 2004). Indeed, it was anticipated that this would reduce possibilities to reverse the project decision but it turned out this was in fact the intended outcome (TCI 2004: 399). This is a clear example how the Cabinet's support strategically acted to keep the project plan from being withdrawn.

A poor problem analysis, as well as actions by the Ministry and the NS led to alternatives not being fairly evaluated, effectively closing alternatives to the Betuweroute project from the decision-making process. The Warnemünde agreement as well as the SVV2 were

made before the formal decision to build was taken, narrowing the decision-making process to the Betuweroute decision path and as such contributing to lock-in formation.

To conclude, all escalation and path dependency determinants of lock-in in the front-end phase were present except for the determinant opportunity cost information. It was not so much the unavailability of information on alternatives that contributed to lock-in in the Betuweroute project, but rather the insufficient consideration of alternatives.

A set of statements were generated that represent the relevant determinants that were identified. In addition, statements related to reversibility of the decision were included to determine decision-makers' level of awareness of lock-in. The statements are presented in Table 3 in "Appendix 1" showing how the statements relate to the (category of) determinant. For example for the category project determinants, statements were generated covering the two determinants expressed preference and information quality.

Participants and data collection

Participants in this study involve (former) politicians, both members of the coalition and opposition parties at the time of the Betuweroute project. This concerns a total of 244 members, and based on availability of contact information, 154 members were asked to participate in the study.

The data were collected by means of an online web-application (FlashQ developed by Hackert and Braehler 2007). Participants received a randomly numbered set of statements. They were provided with a score sheet (see "Q-methodology approach" section), and participants were asked to rank-order the statements according to the extent to which they agreed/disagreed with the statements. The resulting rank-orderings (Q-sorts) are the viewpoints of individuals. They represent the way decision-makers perceive the risk of lock-in and how they attribute certain determinants to the formation of lock-in.

Only few members were closely involved in the decision-making of the project and were therefore able to participate in the study. The politically sensitive subject and people's unfamiliarity with the method may have led to some reluctance to participate. However, the sample size of our study of 15 respondents is similar to that of many other external Q-studies (e.g. Bullington et al. 2007; Hall 2008; Lai et al. 2007; Steelman and Maguire 1999). Besides, the factors derived in our study were highly distinguishable indicating the reliability of the results. As mentioned in the "Research method" section, Q-methodology is a reliable method for small sample studies. The primary purpose of Q-methodology is to identify a typology of perceptions, not to test the percentage of people that share these perceptions. Hence, the number of respondents is rendered relatively unimportant. "As few as 12 participants can generate statistically meaningful results" (Barry and Proops 1999: 344); the resulting typologies of viewpoints are statistically significantly different from one another. Therefore, the response rate is acceptable for this exploratory study.

Correlation and factor analysis

After participants completed the Q-sorting process, we proceeded with the data analysis using PQMethod software (Schmolck 2002). This is a dedicated Q-methodology software package that automatically generates the initial by-person correlation matrix and provides effective processes for factor analysis. First, a by-person correlation procedure was followed in which participants' Q-sorts were correlated. The correlation matrix indicates the relationships between Q-sorts (Watts and Stenner 2005). Subsequently, the resulting

person/Q-sort correlation matrix was factor analysed by Principle Components Factor Analysis. Factor analysis produced a set of factors onto which participants load. The factors are based on the way in which participants rank ordered the statements. Participants that load onto the same factor will have created similar rank orderings. The factors represent the common perceptions of the risk of lock-in. Initially eight factors were extracted. These factors were subjected to Varimax rotation to identify significant, orthogonal (uncorrelated) factors. By convention, only factors with an eigenvalue greater than or equal to 1 and with two or more significant loadings are considered significant.[2] Eigenvalue is a common statistical criterion used in Q-methodology to decide which factors to retain. Any factors with lower eigenvalues than 1 are not considered significant, they may result largely from chance and therefore should be disregarded (Addams 2000: 27). The varimax rotation identified four significant factors (referred to below as factors A–D).

For these remaining four factors, a factor loading was determined for each Q-sort, expressing the extent to which each Q-sort is associated with each factor. Persons with loadings in excess of 2.58 ($1/\sqrt{N}$) (with N = the number of statements) are considered statistically significant at the conventional $p = 0.01$ level (McKeown and Thomas 1988: 50). Significant loadings are thus 'indicative of a meaningful relationship between the participant's Q-sort and the factor type' (Addams 2000: 25). In this study, loadings in excess of ± 0.58 are significant at the $p = 0.01$ level (see Table 1).[3]

Table 1 shows the loadings for each Q-sort on each of the four factors. The Q-sort ID's are participants' rank ordering of statements. For example, Q-Sort 1 is correlated with factor A to the extent of 0.54 whereas Q-sort 2 is correlated on factor A to the extent of 0.40, their loadings are −0.21 and 0.41 respectively on factor B. None of these are significant factor loadings as they do not meet the threshold value of ± 0.58. Instead both Q-sort 1 and 2 have a significant factor loading on factor D. Thus participants 1 and 2 rank ordered the statements in a similar way, they have similar viewpoints that can be represented by factor D.

Factors A–D are four distinct ways in which decision-makers perceive the risk of lock-in. The factor matrix thus reveals convergence and divergence of perceptions. Participants loading on a factor have similar viewpoints but their viewpoints differ from participants who have loaded on any of the other factors.

Factors however do not give us information about the perceptions they represent. In order to describe these four perceptions of risk we computed the ideal type Q-sorts. The Q-sorts of all participants that load on a factor were merged to determine this single ideal Q-sort (Watts and Stenner 2005). The idealised Q-sort is also referred to as 'factor array', it represents the best-estimate of the ordering of the statements for that factor. As such this ordering reveals strong (dis)agreements of statements and overall perception on the topic.

We determined the ideal type Q-sort by converting the factor scores into an array of scores corresponding to those used in the original Q-sort continuum, a range from −3 (disagree most) to +3 (agree most). Table 2 shows these factor arrays for factors A–D. It shows the scores for each of the statements on the four factors (A–D). The table also shows the

[2] An eigenvalue is a measure that reflects the amount of variation accounted for by the corresponding factor. Although a variety of statistical criteria may be used to decide which factors are to be retained as 'real' and significant, the eigenvalue criterion is the most widely used rule (Addams 2000).

[3] Persons with loadings in excess of 1.96 ($1/\sqrt{N}$) (with N = number of statements) are considered statistically significant at the $p = 0.05$ level. Q sort 7 loaded 0.525 on factor 2 which is significant at the $p = 0.05$ level but not at the $p = 0.01$ level.

Table 1 Factor matrix

Q-sort ID[a]	A	B	C	D
1. MC/O9	0.54	−0.21	−0.14	0.64 X
2. FC8	0.40	0.41	0.03	0.65 X
3. MC9	−0.04	0.73 X	0.31	0.28
4. MO8	0.09	0.04	0.05	0.90 X
5. FC1	−0.04	−0.33	−0.77 X	0.02
6. MC9	−0.03	−0.00	0.82 X	0.07
7. MC13	−0.30	0.53 X	0.41	0.03
8. M-13	−0.46	0.80 X	0.08	0.01
9. MO9	0.86 X	−0.11	−0.15	0.16
10. FC14	0.88 X	−0.24	0.02	0.24
11. MC5	0.38	−0.73 X	0.01	0.40
12. MO13	−0.20	0.76 X	0.16	−0.26
13. MC8	0.74 X	−0.00	0.11	0.40
14. MC9	0.40	0.80 X	0.01	0.01
15. MO9	0.32	−0.31	0.10	0.75 X
% explained variance	22	25	11	18

X Indicates that the Q-sort loaded significantly on the factor (A–D respectively). For example both participants 1 and 2 share perception D, whereas the perception of participant 3 is represented by perception B

[a]Following the notation by Watts and Stenner (2014), each participant has a code next to their ID representing the demographic and supporting information relevant for this study. The code for participant 1 is MC/O9. In order of appearance, information is provided about gender (M = male), political party (in this case both as C = coalition, O = opposition party), and years of experience (9 years)

relation between the statement, the category of determinant, and the specific determinant it refers to. The category of determinant refers to the categories of escalation of commitment, organisational path dependency, or awareness. For example, participants who share the risk perception represented by factor C strongly agree with statement 1 (it has a score of +3) whereas participants who share factor B do not have a strong opinion about this statement (score of 0). Figure 5 in "Appendix 2" illustrates the idealized Q-sort for factor A in the score sheet format.

Findings

The previous section has identified four factors and their factor arrays. These represent the four different ways in which decision-makers perceive the risk of lock-in. In this section we describe these perceptions referring to the statement number and factor arrays as (statement number: score). For example reference to (1:3) means statement 1 has a score of 3; participants that share this risk perception strongly agree with statement 1.

Table 2 Factor arrays of four rotated factors

Nos.	Statement	Category of determinant	Determinant	Factor			
				A	B	C	D
1	In 1996, the decision to build was taken, but informally, one or more political parties had already committed themselves to the project	Awareness	Recognition	2	0	3	1
2	Although the decision was not yet taken formally, the immense amount of time put in the project before 1996 made it impossible not to proceed with the project	Psychological	Sunk costs	−1	−2	0	−2
3	In their position towards the Betuweroute, some politicians put their personal interest before social or economic interests	Social	External justification	0	−3	−2	0
4	The commitment to implement the Betuweroute increased by including the project in the policy plan SVV2	Project	Expressed preference	1	1	2	0
5	I felt like alternatives for the Betuweroute (for example inland shipping) could not be discussed	Organisational path dependence	Closure of alternatives	3	−1	−3	3
6	In 1996 the decision to build was taken, but I felt committed to the project much earlier	Awareness	Recognition	−2	1	0	0
7	Even before the formal decision to build was taken in 1996, investments (for example for research) were too large to blow off the project	Psychological	Sunk costs	0	−2	2	−1
8	I would have taken it personally if the decision to build Betuweroute project had not passed	Psychological	Internal justification	−3	0	−3	−2
9	The commitment to implement the Betuweroute increased by including the project in the agreement of Warnemünde	Organisational path dependence	Agreements	1	0	1	1
10	At the time of decision-making in 1996, the available information was sufficient to take a well-advised decision	Project	Information quality	−2	3	0	2
11	The decision to build was rather a strategic decision than a decision based on economic or environmental objectives	Social	External justification	−1	1	3	3
12	I felt I had to justify the decision for the Betuweroute to a larger extent than for other decisions	Psychological	Internal justification	−2	0	−1	−1
13	The many informal promises (made by politicians, ministers etc.) made it impossible in 1996 to take a negative decision regarding the Betuweroute	Organisational path dependence	Agreements	0	−3	−1	1
14	At the time of decision-making in 1996, the Betuweroute was the best solution for the problems with the freight transport	Organisational path dependence	Decision support	−3	2	2	−3

Table 2 (continued)

Nos.	Statement	Category of determinant	Determinant	Factor			
				A	B	C	D
15	Pressure was put on individuals within political parties to support the Betuweroute project	Structural	Political support	2	−1	0	0
16	The underpinning of the necessity of the Betuweroute was improved due to social pressures in the period before the decision to build in 1996	Social	Resistance	1	2	1	−1
17	The perseverance of decision-makers towards the project was so large that there was no other option than to continue	Awareness	Recognition	2	−2	−1	−2
18	At the time of decision-making in 1996, the underpinnings for the utility and necessity of the Betuweroute were sufficient	Project	Information quality	−1	3	−2	−3
19	Critiques from society in the period before the decision to build in 1996 led to a decrease of support of the decision	Social	Resistance	0	2	1	2
20	The solution in the form of the Betuweroute project was the starting point of discussion rather than the problems for which the Betuweroute would serve as a solution	Project	Expressed preference	2	−1	−2	2

Perception A

Participants in this category believe that the project was the starting point instead of the problems with inefficient capacity for freight transport (20:2). Alternatives were not given a fair chance (5:3). “Initiators were not interested in alternatives and there was a strong lobby for the Betuweroute project.” This illustrates how the preference for the project contributed to lock-in. Individuals also considered political support to have played a role to some extent (15:2). “There was no unanimity within parties and agreement was enforced.” In addition, the information that was available at the time was not considered sufficient to make a well-advised decision (10: -2). However, participants dismiss self-justification as a cause of lock-in (8: -3, 12: -2). The participants clearly show some level of regret over previous options not being taking, suggesting risk-averse decision-makers. They assessed the risk of lock-in mostly through the determinants expressed preference, political support, and information quality. The participants are experienced decision-makers (8–14 years in ruling Cabinets) from different political parties in coalition and opposition.

Perception B

According to participants in this category expressed preference (20: -1) did not play a role, rather alternatives were considered to be inferior to the Betuweroute. “The choice for the Betuweroute was inevitable to reduce freight traffic by road. Inland shipping did not have the necessary potential.” Subjects deemed the available information sufficient to make a justified decision (10:3); “more information would not have led to a different decision.” The need for the project was proven (18:3). “The necessity of the Betuweroute was clear; information was mainly needed for the implementation.” Besides, psychological and social determinants were also dismissed as having contributed to lock-in. The participants do not support any determinants resulting in lock-in and as such they do not acknowledge the risk of lock-in. They could be considered risk-seeking as they have no apparent regret over decisions taken or previous options available. The participants sharing this perception are all males, with an average experience of 10 years covering three Cabinet periods. All except one represent coalition political parties.

Perception C

Participants that share this viewpoint believe that the economic and environmental justification for the project was weak (11:3). Subjects quite strongly believe alternatives were considered (5: -3). “Alternatives were discussed extensively but I am convinced they did not suffice.” This suggests a level of regret over the robustness of previous analyses but it also displays some level of minimax behaviour in that participants believed that putting the project in the policy plans gave it a favourable position over other projects (4:2). Similarly, subjects accepted that the lack of information could have influenced the project planning (18: -2) and that investments were too large to withdraw the project (7:2). Participants that share this perception feel some level of regret and can be considered risk-averse. They consider the risk of lock-in mostly due to the role information quality and sunk costs. The participants are varied across gender and experience. They represents different political parties albeit they are all coalition parties.

Perception D

All subjects in this category believe there was a clear preference for the project (20:2) and have some regret that potential feasible alternatives such as inland shipping were not given a fair evaluation. “The Betuweroute was a project of prestige.” “The Betuweroute had to be implemented no matter what. It was only a strategic project to strengthen the image of the Harbour of Rotterdam.” This suggests external justification played a role (11:3). Furthermore, subjects do not believe that the utility and necessity of the project was sufficiently examined (18: -3). “The financial arguments were flawed.” Agreements are considered to have played a minor role in the creation of lock-in whereas psychological determinants were generally dismissed. The clear feeling of regret shown by these participants suggests they are risk-averse. Their risk preference is mostly shaped by their attitude towards the role of expressed preference, external justification, closure of alternatives, agreements, and decision support in the formation of lock-in. Participants sharing this perception are experienced decision-makers (8–9 years covering at least two Cabinet periods). They represent different political parties mostly opposition parties.

Discussion and implications

Decision-makers’ perceptions of the risk of lock-in

Risk perception of lock-in formed by escalation of commitment. Participants in this study perceived project determinants as most influential in the risk of lock-in. Yet there is a lack of consensus about the contribution of information quality on the formation of lock-in. This opposing view can be explained by the concept of contested information, information that is “controversial, disputable, difficult to measure objectively or even non-existent” (De Bruijn and Leijten 2007: 50–51). Decision-makers disputed whether information was sufficient to take a decision, whereby those who believed information was sufficient, may have been selective in using only information that fitted their beliefs.

Some decision-makers identified expressed preference for the project plan as a key determinant of lock-in. This is a common problem with (major) projects when project proposals are taken as a starting point rather than selected as the result of a thorough problem analysis comparing different project options (Giezen 2013).

Risk perception of lock-in formed by path dependence

We found that if decision-makers perceive a situation positively and hence support the decision, they are less likely to perceive lock-in as a risk. Confirmation bias may explain the relation between decision support and lock-in. It is “the tendency to search for, interpret, favour, and recall information in a way that confirms one’s pre-existing beliefs” (Plous 1993: 233). This implies decision-makers who support the decision are less critical and tend to use information that fits their (positive) viewpoint of the decision and consequently are more vulnerable to lock-in. Conversely, decision-makers who were critical towards the project decision perceived the risk of lock-in to be higher. This complements the findings of previous studies. For instance, Wong (2005) found that when individuals perceive a situation as negative they will be more risk-averse and less likely to continue with that

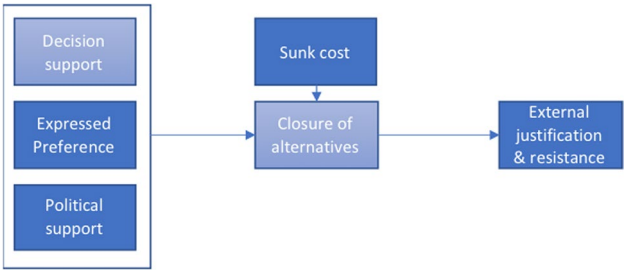

Fig. 4 Updated model of relations between escalation of commitment (dark shaded) and path dependency (light shaded) determinants

decision path. Besides decision support, the closure of alternatives played a large role in the way in which decision-makers perceived the risk of lock-in whereas agreements had little contribution.

Relation between escalation of commitment and path dependency determinants

The findings reveal some interplay between the escalation of commitment and path dependency determinants. Figure 4 shows the updated model and relations as perceived by decision-makers in this study.

First of all there is a clear relation between decision support and closure of alternatives. Participants who supported the project decision generally did not acknowledge the role of closure of alternatives. Considering the relation between closure of alternatives and the escalation of commitment determinants, there is a clear relation with expressed preference although we cannot test for the causality of the relation. Participants who agreed that closure of alternatives played a role also believe expressed preferences played a role, and vice versa. There is also a relation with political support; people agreeing closure of alternatives played a role also believed political support contributed to this. However, the result should be approached with caution as decision-makers did not have strong opinions about this determinant.

There is some interplay between the external justification and resistance determinants and closure of alternatives. For example, the results showed a negative relation between closure of alternatives and improved underpinning of the project; decision-makers who acknowledged closure of alternatives also believed the underpinning for the project had not improved.

There seems to be a negative relation between sunk costs and closure of alternatives, participants either attributed the lock-in process to closure of alternatives or to sunk costs, but not a combination of both determinants.

The data did not provide evidence for any relation between self-justification and closure of alternatives, possibly because self-justification was generally dismissed as a determinant. Lastly, the data could not confirm or dismiss a relation between agreements as a path dependency determinant and any of the escalation of commitment determinants because participants did not have a clear view about the role of agreements in the formation of lock-in.

Recognition of lock-in. From the discussion above we can conclude that many determinants were not acknowledged by decision-makers, illustrating that they do not fully recognise the risk of lock-in. Another way to examine decision-makers perception of the risk of lock-in is by considering the extent to which they are aware that lock-in occurred and resulted in irreversibility of the project decision. This study revealed both decision-makers who were aware as well as decision-makers who were unaware of the lock-in process. This confirms previous studies into risk awareness such as Cantarelli et al. (2010) who differentiate between conscious and unconscious lock-in. Moreover, the awareness of lock-in is also present in situations characterised by warranted continuation. Decision-makers who were aware of lock-in believed that even though a formal decision had not yet taken place, it was no longer possible to reverse the project decision.

Implications

This study has shown that decision-makers in three of the four perceptions on the risk of lock-in were to some extent risk-averse. Minimax regret theory suggests risk averseness will increase the level of regret of missing out on possible alternative projects and hence decision-makers would choose to withdraw from the project decision to minimise their extent of regret. However, this study has shown that this has actually not occurred and it can be argued that the level of decision-makers' risk aversion was not sufficiently acute to drive the level of regret needed to take the decision to withdraw the project plan.

In fact, the level of risk averseness is moderated because most decision-makers do not fully recognise how lock-in emerges in the planning of projects and as such fail to recognise the significance of the lock-in risk. They either do not notice determinants causing lock-in or they may not affiliate certain determinants to lock-in formation. This finding fits with current literature which points towards an inverse relation between problem recognition and lock-in (Keil, Depledge and Rai 2007).

The findings imply that when decision-makers do not fully assess the risk of lock-in they are more vulnerable to either escalate their commitment to a project decision (Nathanson et al. 1982; Jani 2011) or incrementally reinforce a decision path towards a set lock-in outcome. It shows how decision-makers' perceptions of lock-in are a mediating factor in the formation of lock-in; underestimation of lock-in risk would increase likelihood of persistence (Keil et al. 2000; Kahneman and Tversky 1979).

The underestimation of the risk of lock-in may point to honest ignorance but it may also be the result of strategic behaviour, that is intentionally underestimating the risk of lock-in when decision-makers have an interest in seeing the project realised (intentional lock-in) (Cantarelli et al. 2010). Similar to Sydow et al. (2010: 175) path development involves "mindful actions of agents who may or may not purposively plan for path dependence". Strategic behaviour can influence the formation of lock-in via escalation of commitment tendency through the misrepresentation of project's costs and benefits (Flyvbjerg et al. 2003; Winch 2013). It can influence the path dependence process by the tendency of decision-makers to make agreements in line with the expected (preferred) path/decision thereby (intentionally) reducing the chance of alternative options being selected.

Practical implications

The finding that lock-in already occurs in the front-end phase is important for decision-makers and stakeholders because it shows that measures should be put in place to avoid and mitigate the risk of lock-in much earlier than so far has been done. Most strategies to deal with lock-in are focused on the implementation phase and consequently will not be effective to deal with the different nature of lock-in in the front-end. Moreover, adopting a path creating strategy whereby decision-makers collaborate to deviate from the inefficient path has been proven to be effective (Garud and Karnoe 2001). However, our study showed that decision-makers often do not realise the current or planned decision path is inferior to potential others, hence such a strategy would not be adopted or it would not be effectively utilised, as its need is not recognised. This study thus illustrates the need for decision-makers to be alerted to the risk of lock-in and its consequences. It is only when decision-makers perceive the risk of lock-in, that they are more likely to be discouraged to persist with a course of action (Schaubroeck and Davis 1994; Drummond 2017). Only then will measures put in place to eliminate lock-in become fully effective (Hammond et al. 1998; Drummond 2014). In addition, there is a need to amend decision-making and planning processes to include checkpoints that ensure the process is not liable to lock-in developments. These could be part of the quality assurance checkpoints such as those seen in the Norwegian Governance regime or the quality assurance review process in the Governance model of the UK (Volden and Samset 2017). Outsiders, people not associated with the project in any way, are recommended for this evaluation. Acknowledging some of the problems that may arise with the involvement of outsiders (Pinto 2019), outsiders are generally better able to objectively assess risks compared to insiders because they do not have attachment to the project or the decision-making process (Keil et al. 2008).

Limitations and future research

This study has focused on determinants previously identified in the literature and it was not the intention to identify new determinants. Rather, this paper aimed to illustrate that the temporal ordering of determinants already exist in the front-end phase before the decision is made to implement a project. Future research is recommended to identify possible new lock-in determinants in the front-end phase such as the influence of stakeholders' attributes of power, urgency and legitimacy on the formation of lock-in. Moreover, our study showed some first indications of the interplay between the escalation of commitment and path dependency determinants. However, future research is recommended to explore and validate these relations in other settings.

The result of a Q-methodology study reveals the perspectives on an issue but it does not show how widely held these perspectives are in a population (McKeown and Thomas 1988; Webler et al. 2009). It does not generate results that can be generalised to the entire population (McKeown and Thomas 1988), in our case to all relevant decision-makers on the Betuweroute. The value of Q-methodology lies in revealing the underlying viewpoints (by the extracted factors) on a particular topic, and these do not occur beyond the immediate set of participants. Generalisation in Q-methodology studies occurs at the level of the set of participants (Valenta and Wigger 1997) whereby each of the extracted factors is a generalisation of the viewpoint held by the persons that define them (Dryzek 2005). In our study the four factors that have been extracted are generalisations of the way of thinking

about the risk of lock-in in the Betuweroute project. Future research is recommended into the perceived risk of lock-in in other projects and the prevalence of viewpoints on lock-in risk among the larger population of decision-makers by conducting large group surveys (Valenta and Wigger 1997).

Considering our finding of perceived risk as a contributing determinant in the formation of lock-in, we recommend to carry out further research into this new determinant, for example extended research into the relative strength of contributing determinants and how the risk of lock-in is perceived in other phases of the project life cycle.

Conclusion

This study makes two main contributions to the current knowledge on lock-in in major transportation projects. First, we have identified several escalation and path dependency determinants that may result in lock-in in the front-end phase of major transportation projects, a phase that is not yet clearly understood in the escalation of commitment and project management disciplines (He and Mittal 2007; Williams et al. 2019). Relevant escalation of commitment determinants include expressed preference, need for justification, sunk costs, external justification, resistance, and political support. Relevant path dependency determinants include closure of alternatives, agreements, and decision support. Moreover, the study also provided some first insights into the interaction between escalation of commitment and path dependency determinants. Particularly there is a strong influence between the path dependency determinants decision support and closure of alternatives. There are also various relations between closure of alternatives and the following escalation of commitment determinants: expressed preference, sunk costs, external justification, resistance and political support. As such we provide a more comprehensive understanding of lock-in formation and show the need to extend the theoretical model of lock-in to include the front-end phase.

Secondly, we have shown that risk attitudes vary across decision-makers depending on their perception of the determinants that causes this lock-in and the extent to which they recognise the risk of becoming locked-in to a project decision-making path. According to the decision-makers, the most influential determinants in the formation of lock-in include expressed preference, information quality, decision support and closure of alternatives. In contrast, need for justification and agreements did not contribute to lock-in. The extent to which decision-makers recognised determinants distinguished the four perceptions of the risk of lock-in.

This study illustrates the need to include risk perception as an additional determinant in the framework of lock-in. We have shown that underestimating the risk of lock-in may contribute to lock-in formation and prevalence of poor project performance in major projects.

Table 3 Statement and link with determinants

Statement	Category of determinant	Determinant	Nos.
The commitment to implement the Betuweroute increased by including the project in the policy plan SVV2	Project	Expressed preference	4
The solution in the form of the Betuweroute project was the starting point of discussion rather than the problems for which the Betuweroute would serve as a solution	Project	Expressed preference	20
At the time of decision-making in 1996, the underpinnings for the utility and necessity of the Betuweroute were sufficient	Project	Information quality	18
At the time of decision-making in 1996, the available information was sufficient to take a well-advised decision	Project	Information quality	10
I would have taken it personally if the decision to build Betuweroute project had not passed	Psychological	Internal justification	8
I felt I had to justify the decision for the Betuweroute to a larger extent than for other decisions	Psychological	Internal justification	12
Although the decision was not yet taken formally, the immense amount of time put in the project before 1996 made it impossible not to proceed with the project	Psychological	Sunk costs	2
Even before the formal decision to build was taken in 1996, investments (for amongst other research) were too large to blow off the project	Psychological	Sunk costs	7
In their position towards the Betuweroute, some politicians put their personal interest before social or economic interests	Social	External justification	3
The decision to build was rather a strategic decision than a decision based on economic or environmental objectives	Social	External justification	11
The underpinning of the necessity of the Betuweroute was improved due to social pressures in the period before the decision to build in 1996	Social	Resistance	16
Critiques from society in the period before the decision to build in 1996 led to a decrease of support of the decision	Social	Resistance	19
Pressure was put on individuals within political parties to support the Betuweroute project	Structural	Political support	15
I felt like alternatives for the Betuweroute (for example inland shipping) could not be discussed	Organisational path dependence	Closure of alternatives	5
The commitment to implement the Betuweroute increased by including the project in the agreement of Warnemünde	Organisational path dependence	Agreements	9
The many informal promises (made by politicians, ministers etc.) made it impossible in 1996 to take a negative decision regarding the Betuweroute	Organisational path dependence	Agreements	13

Table 3 (continued)

Statement	Category of determinant	Determinant	Nos.
At the time of decision-making in 1996, the Betuweroute was the best solution for the problems with the freight transport	Organisational path dependence	Decision support	14
In 1996, the decision to build was taken, but informally, one or more political parties had already committed themselves to the project	Awareness	Recognition	1
In 1996 the decision to build was taken, but I felt committed to the project much earlier	Awareness	Recognition	6
The perseverance of decision-makers towards the project was so large that there was no other option than to continue	Awareness	Recognition	17

Appendix 1

Statements

Table 3 shows the statements and their relation with the determinant of lock-in. The cate-

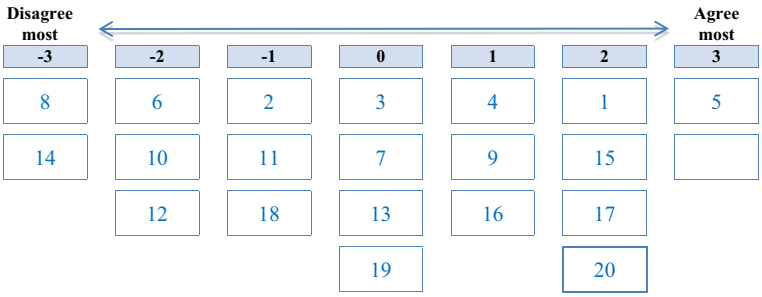

Fig. 5 Idealized Q-sort Factor A

gory of determinant refers to any of the four categories of escalation of commitment, organisational path dependency, or awareness. The statements have been randomly numbered.

Appendix 2

Figure 5 shows how a hypothetical person with a 100 percent loading on factor A would have rank ordered the 20 statements.

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